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## CHARACTERISTICS OF SPOTTED OWL NEST TREES IN THE WENATCHEE NATIONAL FOREST


JOSEPH B. BUCHANAN[1] AND LARRY L. IRWIN
*National Council of the Paper Industry for Air and Stream Improvement, 720 S.W. Fourth, Corvallis, OR 97339 U.S.A.*

EDWIN L. MCCUTCHEN[2]
*U.S. Forest Service, Wenatchee National Forest, P.O. Box 811, Wenatchee, WA 98801 U.S.A.*



ABSTRACT.—This study describes Spotted Owl (*Strix occidentalis*) nests and nest trees on the east slope of the Cascade Mountains in Washington. We collected data at 85 nest trees and made comparisons of 62 paired nest- and randomly-selected trees. More nests (92%) were in Douglas-fir trees (*Pseudotsuga menziesii*) than expected in comparison to other tree species in the stand. Most nest trees occupied either dominant or codominant canopy positions, and were typically alive and fully intact. Nest trees ranged from 66–700 yr of age; the median age was 137 yr. Nest trees on south-facing slopes were significantly larger in diameter and older than those on north-facing slopes. Trees with cavity and broken-top platform nests were significantly larger in diameter and older than trees that supported other types of nests. Nests originally made by Northern Goshawks (*Accipiter gentilis*) were the most common nest type used by Spotted Owls (55.3%); other nests were located in mistletoe growth (24.7%), in cavities (10.6%), on broken-tops (5.9%), and on large branches (3.5%). The relatively young age and smaller diameter of nest trees used by Spotted Owls in the eastern Cascades is consistent with the characteristics of stands used for nesting and is likely a result of the fire history of this region. The presence of mistletoe clumps and goshawk nests may facilitate occupancy of younger stands that otherwise lack nesting structures.


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Características de los árboles donde el búho *Strix occidentalis* construye su nido, en la Wenatchee National Forest

EXTRACTO.—Este estudio describe los nidos, y los árboles donde éstos se construyen, del búho *Strix occidentalis,* en la pendiente oriental de las Montañas Cascade, en Washington. Hemos colectado data de 85 árboles con nidos, y hemos hecho comparaciones de 62 de ellos con otros árboles seleccionados al azar. Más nidos (92%) de los que se esperaba estuvieron en árboles de la especie *Pseudotsuga menziesii,* en comparación con otras especies de árboles de la muestra. La mayoría de árboles con nidos ocuparon posiciones de copa dominante o co-dominante, y fueron típicamente árboles con vida y plenamente intactos. La edad de los árboles con nidos fluctuó entre 66 y 700 años. La media de las edades fue de 137 años. Los árboles en las pendientes que dan al sur fueron significativamente más grandes y más viejos que los de las pendientes que dan al norte. Tanto los árboles con cavidades como los que ofrecen plataforma en el tronco de extremo superior roto, fueron significativamente más grandes y más viejos que los árboles que sostenían otros tipos de nidos. Los nidos construídos originalmente por el Gavilán Azor (*Accipiter gentilis*) constituyeron el tipo de nido más comunmente usado por los *S. occidentalis* (55.3%); otros nidos fueron ubicados en muérdagos (24.7%); en cavidades (10.6%); en extremos rotos (5.9%) y en grandes ramas (3.5%). La relativa tierna edad y el poco diámetro de los árboles


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[1] Present address: Washington Department of Wildlife, Wildlife Management Division, 600 Capitol Way North, Olympia, WA 98501 U.S.A.

[2] Present address: U.S. Forest Service, Rangeland Management and Ecology, 517 Gold S.W., Albuquerque, NM 87102 U.S.A.

usados por los *S. occidentalis* en las Montañas Cascade del este, son consistentes con las características de los grupos de árboles usados por estos búhos para anidar, y es posiblemente el resultado de la historia de incendios de esta región. Puede que la presencia de muérdagos y de nidos de Gavilán Azor en árboles jóvenes promueva el uso de florestas nuevas.

[Traducción de Eudoxio Paredes-Ruiz]

Spotted Owls (*Strix occidentalis*) generally nest in old forests characterized by large old trees, large volumes of dead and downed wood, abundant snags, and multi-storied canopies (Forsman et al. 1984). However, in the Wenatchee National Forest (WNF), where fire has strongly influenced the forest landscape (Cobb 1988), Spotted Owls nest in relatively young stands (Buchanan 1991). The characteristics of nest sites in the WNF will be described elsewhere. Here, we describe the nest trees and nest structures used by Spotted Owls on the east slope of the Cascade Mountains in Washington.

## STUDY AREA

Our study was conducted on the east slope of the Cascade Mountains in Washington, primarily on the WNF, but including sites under various land ownerships in the region. Much of the WNF is mixed coniferous forest (Franklin and Dyrness 1973, Cobb 1988). The dominant species are Douglas-fir (*Pseudotsuga menziesii*) and Grand Fir (*Abies grandis*), although Ponderosa Pine (*Pinus ponderosa*), Western Larch (*Larix occidentalis*), Lodgepole Pine (*P. contorta*), White Pine (*P. monticola*), Western Redcedar (*Thuja plicata*), and Western Hemlock (*Tsuga heterophylla*) are locally abundant (Cobb 1988).

## METHODS

**Data Collection.** We examined 85 of 103 known Spotted Owl nests from 1988–90, all but four of which contained fledgling owls at least one of the previous four yr.

To evaluate use of nest trees relative to availability at the stand level we collected data at single randomly selected trees located within 400 m of 62 nest trees. For this comparison we included only trees >28 cm diameter at breast height (dbh) because this was the size of the smallest nest tree and we assumed that trees below this size were generally unsuitable for nesting (see Buchanan 1991 for additional details on selection of random trees and plots).

We identified nest tree species and described their condition (e.g., alive or dead, intact or broken stem). Canopy position was determined as dominant, codominant, intermediate, suppressed, or no canopy (e.g., absence of living canopy foliage within the 0.04-ha sampling plot; see Buchanan 1991). The presence of dwarf mistletoe (*Arceuthobium douglasii*) in each nest tree was rated as none, moderate, or high infection in the upper, middle, and lower thirds of the canopy (see Hawksworth and Wiens 1972).

The age of the nest tree was determined by counting growth rings of an increment core taken at breast height. We measured dbh with a diameter tape. A clinometer was used to determine tree, nest, and canopy height. We recorded nest exposure (azimuth) and categorized the nest type (e.g., cavity, mistletoe broom, abandoned hawk nest).

**Statistical Analysis.** We used paired-sample $t$-tests and the Wilcoxon matched-pair test (Wilkinson 1988), depending on whether transformations were successful in creating normal distributions, to evaluate differences between 62 nest and random comparison trees. Chi-square analysis (including contingency tables) was used to compare categorical variables Because nest exposure was not strongly polymodal we used Rayleigh's test (Batschelet 1981) rather than Rao's spacing test (Bergin 1991) to evaluate the angular distribution. We used the Watson-Williams test to evaluate the relationship between the mean angles of site aspect and nest orientation (Batschelet 1981).

## RESULTS

With seven exceptions, Spotted Owls nested exclusively in Douglas-fir trees (Table 1). At paired sites, we found a significant difference in the proportion of used and available tree species. Douglas-fir was used more than expected and all other species combined were used less than expected ($\chi^2 = 22.2$, $P < 0.001$). Most nest trees were either dominant or codominant in the canopy; this was generally true for random trees as well, although the greater number of random trees in intermediate canopy positions (Table 2) resulted in a difference between nest and random trees that was significant at $P = 0.057$ ($\chi^2 = 3.66$, df = 2). The condition of nest and random trees also differed significantly ($\chi^2 = 4.6$, $P = 0.034$), as there were relatively more live, intact random trees and live nest trees with broken tops (Table 3).

Nest trees ranged from 66–700 yr of age; the median nest tree age was 137 yr (Fig. 1). Nest tree age was significantly greater (at $P = 0.064$) than the age of randomly selected trees (Table 4). The 35 nest trees on south-facing slopes were significantly older than 50 on north-facing slopes (median age for south = 165 yr, range = 66–700 yr; median age for north = 127 yr, range = 67–550; Mann-Whitney test, $Z = 2.71$, $P = 0.007$). The median age of 14 cavity and broken-top nest trees (282 yr, range = 135–700) was significantly greater than the 71 others (120 yr, range = 66–545; Mann-Whitney test, $Z = 5.28$, $P < 0.001$). In summary, 11 of 14 (78.6%) cavity and broken-top nests were in trees >200 yr old and 63 (88.7%) of the

Table 1. Tree species used for nest sites, and a comparison of the number used and "available" at randomly sampled Spotted Owl nest stands and sites in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

| SPECIES | ALL NESTS[b] | % | PAIRED SITES[a] NEST | RANDOM |
|---|---|---|---|---|
| Douglas-fir | 78 | 91.8 | 56 | 31 |
| White Pine | 2 | 2.4 | 2 | 0 |
| Grand Fir | 1 | 1.2 | 0 | 18 |
| Western Larch | 1 | 1.2 | 1 | 6 |
| Ponderosa Pine | 1 | 1.2 | 1 | 4 |
| Western Redcedar | 1 | 1.2 | 1 | 0 |
| Western Hemlock | 1 | 1.2 | 1 | 1 |
| Pacific Silver Fir | 0 | 0.0 | 0 | 1 |
| Engelmann Spruce | 0 | 0.0 | 0 | 1 |

[a] $N = 62$ paired sites.
[b] $N = 85$ total nest sites.

71 remaining nests were in trees <200 yr old; 50% of the nest trees were <130 yr old.

Eleven nest trees were residuals from previous stands largely destroyed by fire. The age of those 11 nest trees (mean = 314.7 yr, SD = 135.5, range = 155–550) was significantly greater than the age of the canopy dominant/codominant trees at each of these sites (mean = 135.6 yr, SD = 63.7, range = 77–228; $t = 4.87$, $P < 0.001$).

Nest trees were significantly larger (dbh) than random trees (Table 4, Fig. 2). In addition, nest trees on south-facing slopes were significantly larger (dbh mean = 76.4 cm, $N = 35$, SD = 30.5) than those on north slopes (mean = 58.2 cm, $N = 50$, SD = 18.8; Mann-Whitney test, $Z = 3.11$, $P = 0.002$). The 14 cavity/broken-top trees were significantly larger (mean = 94.7 cm, SD = 23.1) than the 71 others (mean = 59.4 cm, SD = 21.8; Mann-Whitney test, $Z = 5.39$, $P < 0.001$). Eight of nine cavity nest trees and two of five nest trees with broken-tops were on south slopes.

Table 2. Canopy position of Spotted Owl nest and random trees in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

| CANOPY POSITION | ENTIRE SAMPLE | PAIRED SAMPLE NEST | RANDOM |
|---|---|---|---|
| Dominant | 24 | 15 | 13 |
| Codominant | 48 | 37 | 30 |
| Intermediate | 6 | 5 | 18 |
| Suppressed | 1 | 1 | 0 |
| No crown | 4 | 4 | 1 |

Table 3. Status of Spotted Owl nest and randomly selected trees in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

| STATUS | ENTIRE SAMPLE | PAIRED SAMPLE NEST | RANDOM |
|---|---|---|---|
| Alive with intact top | 59 | 43 | 53 |
| Alive with intact, dead top | 2 | 1 | 2 |
| Alive with broken top | 14 | 11 | 4 |
| Dead with intact top | 4 | 3 | 2 |
| Dead with broken top | 4 | 4 | 1 |

Nest tree height was not significantly different than the height of random trees (Table 4). Nest trees ranged from 7 (a broken snag) to 50 m tall. The height to the base of the canopy was significantly greater in nest trees than in random trees (Table 4). The mean height of nests was 16.9 m (SD = 6.9, range = 6.4–41.5). The position of nests in the canopy was variable, and appeared to be related to nest type (Table 5). Most nests (93%) occurred in the middle and lower canopy or the sub-canopy. Most nests (84.7%) were either on or immediately adjacent to the trunk. Eleven of 13

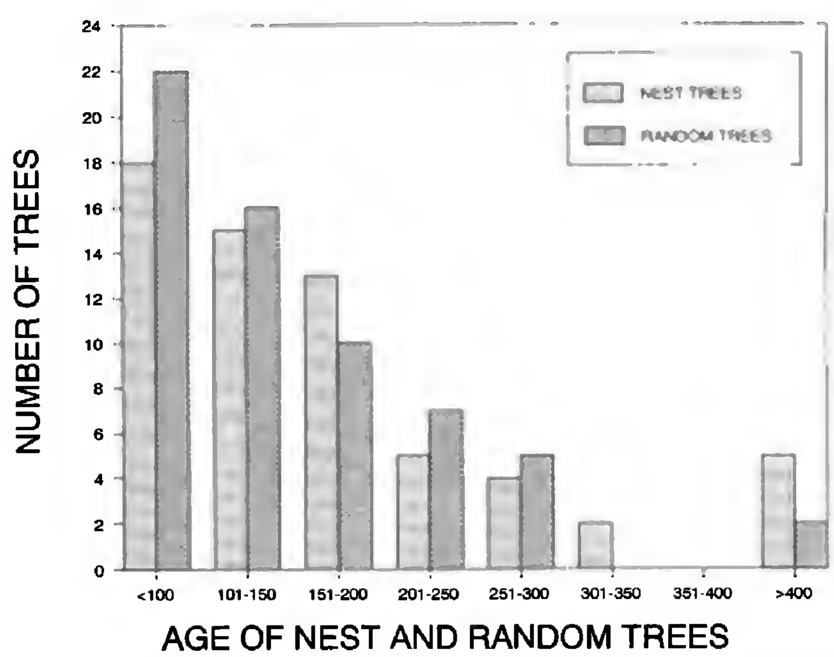


Figure 1. Frequency distributions of the age of Spotted Owl nest trees and randomly selected trees at 62 paired sites in the eastern Cascade Mountains, Washington.

Table 4. Comparison of Spotted Owl nest and random tree age, dbh (cm), and height (m) parameters from the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison. Standard deviations are in parentheses. *P* values based on paired analyses.

| PARAMETER | ENTIRE SAMPLE | PAIRED SAMPLE NEST | RANDOM | *P* |
|---|---|---|---|---|
| Tree age[a] | 137.0 | 147.0 | 124.0 | 0.064 |
| dbh | 65.8 | 66.5 | 53.1 | <0.001 |
| | (25.7) | (25.9) | (20.6) | |
| Total height | 31.0 | 30.4 | 28.6 | 0.190 |
| | (8.0) | (8.2) | (7.3) | |
| Canopy height | 15.5 | 15.7 | 13.0 | 0.005 |
| | (5.2) | (5.6) | (5.6) | |

[a] Values reported are medians. The median is a more appropriate descriptor because of the highly skewed distribution.

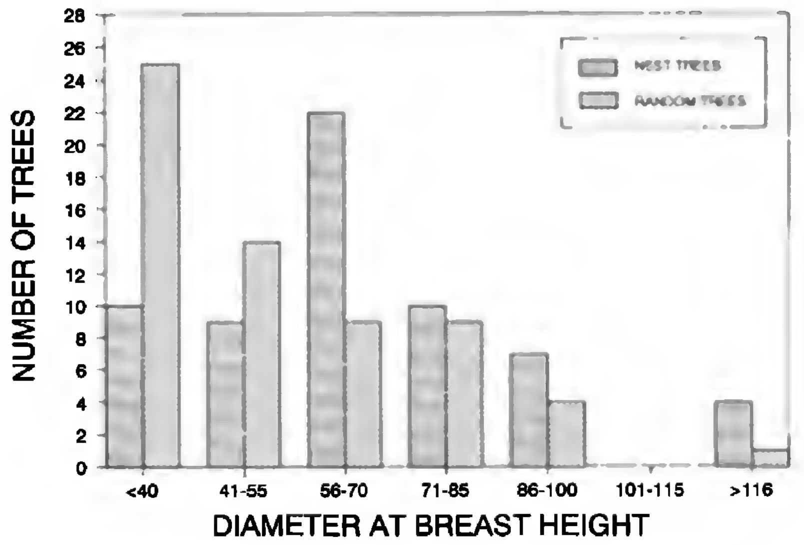


Figure 2. Frequency distributions of the diameter (cm) of Spotted Owl nest trees and randomly selected trees at 62 paired sites in the eastern Cascade Mountains, Washington.

other nests were <1 m from the trunk and the remaining 2 were <2 m from the trunk.

Although Spotted Owls used a variety of nest types, 2 types were more common than others: 47 (55%) were abandoned accipiter nests and 21 (25%) were within mistletoe brooms (not associated with an accipiter nest; see below). Most of the stick nests appeared to have been made by Northern Goshawks (*A. gentilis*). None of the randomly selected comparison trees contained nests. Because 35 (74%) of the abandoned accipiter nests were on mistletoe brooms, 56 (66%) Spotted Owl nests were either on or within mistletoe growth; this may be a slight underestimate because it was difficult to observe the upper surface of some mistletoe brooms. Other nests were in cavities (9), natural broken-top platforms (5), and on large branches adjacent to the trunk (3). The distribution of cavity and broken-top nests was significantly closer (mean = 19.0 km, SD = 12.7) to the Cascade Mountain crest than was that for hawk and mistletoe nests (mean = 30.9 km, SD = 13.7, $t$ = 2.9, $P$ = 0.005).

The mean angle of nest exposure relative to the trunk was southeast (mean angle = 131.9°, s [angular deviation] = 65.2°, r [a measure of concentration] = 0.35), and was significantly nonrandom ($Z$ = 10.3, $P$ < 0.001; Fig. 3). The mean angle for the sample of accipiter nests ($N$ = 47) did not differ from this (mean angle = 128.1°, s = 68.5°, r = 0.29). The difference between slope aspect (20.1°; Buchanan 1991) and nest exposure was highly significant ($F$ = 28.5, $P$ < 0.001).

## DISCUSSION

Contrary to results from other regions in the Pacific Northwest, we found that Spotted Owls on the east slope of the Cascade Mountains in Washington nest in relatively smaller (e.g., 52% of nest trees were 53–76 cm dbh) and younger (median age = 137 yr) nest

Table 5. Position of Spotted Owl nests in canopy according to nest type (eastern Cascade Mountains, Washington).

| NEST TYPE | CANOPY POSITION TOP ⅓ | MID ⅓ | LOW ⅓ | BELOW | NO CANOPY | *N* |
|---|---|---|---|---|---|---|
| Stick nest[a] | 0 | 5 | 31 | 9 | 2 | 47 |
| Mistletoe | 1 | 4 | 14 | 2 | 0 | 21 |
| Cavity | 0 | 2 | 4 | 3 | 0 | 9 |
| Broken-top | 0 | 2 | 0 | 0 | 3 | 5 |
| Branch | 0 | 0 | 3 | 0 | 0 | 3 |
| Total | 1 | 13 | 52 | 14 | 5 | 85 |

[a] Includes 35 stick nests placed on top of small mistletoe clumps.

trees. This is consistent with Spotted Owl habitat use in this region, where relatively younger forests are available and used for nesting (Buchanan 1991). Consequently, comparisons of nest tree height and age between the WNF and study areas in Oregon (Forsman et al. 1984) and California (LaHaye 1988) reveal substantial differences that reflect differing regional patterns of disturbance, climate, and tree growth. Other nest tree characteristics appear similar to nest sites throughout the Pacific Northwest. In addition, there are a number of similarities to tree use by Northern Goshawks in the region; these are discussed below.

In our study, 92% of the nests were in Douglas-firs, and 88% of all trees were alive. Spotted Owls in Oregon and California nest almost exclusively in Douglas-firs (87% and 83%, respectively), most of which were alive (Forsman et al. 1984, LaHaye 1988). This is similar to findings for Northern Goshawks in this region (Reynolds et al. 1982, Moore and Henny 1983, Hayward and Escano 1989). This apparent preference for Douglas-fir can be explained partly by the observation that mistletoe infection is most prevalent in this tree species in the eastern Cascades (Knutson and Tinnin 1980). In addition, Douglas-fir may have branching characteristics that make them preferred sites for accipiter nest placement (but see Reynolds et al. 1982). Such selection for nest placement by accipiters may be influenced by the presence of mistletoe infections (Moore and Henny 1983).

The location within nest trees of cavity and broken-top nests in our study varied, but most mistletoe and stick nests were in the lower third of the canopy. We found only one nest in the upper third of the canopy. Forsman et al. (1984) noted that cavity nests occurred in the mid- to upper-third of the canopy and that platform nests were in the lower third. Use of stick nests located on lower portions of slopes (Buchanan 1991) represents typical nest placement by Northern Goshawks in the region (Hayward and Escano 1989).

Nest orientation relative to the tree trunk was southerly in our study (132°), as it is in California (201°; LaHaye 1988). This is similar to nest exposure data for Northern Goshawks in eastern Oregon (Reynolds et al. 1982, Moore and Henny 1983). Although 57% of the nests in our study were on north slopes, nest exposure at 63% of the sites was southerly. The primary reason for this was that most nests were on the uphill side of the tree. This upslope placement may be related to prey delivery behavior of Northern Goshawks. However, this does not fully explain the apparent preference for ESE and SE exposures. This

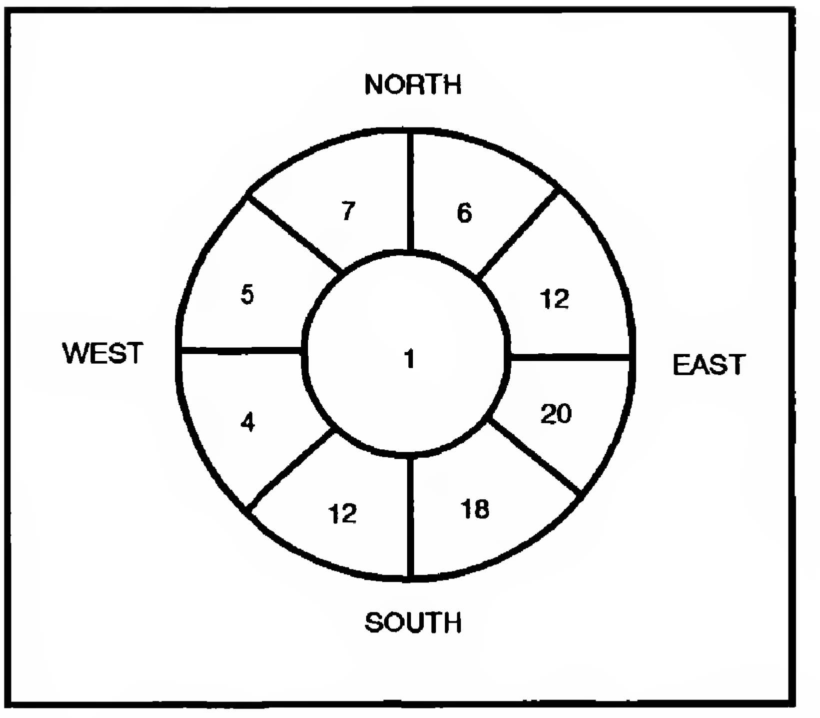


Figure 3. Frequency distribution of nest exposure at 85 Spotted Owl nest trees in the eastern Cascade Mountains, Washington.

apparent preference for nest exposure may reflect other important factors (e.g., protection from prevailing storm patterns, optimal thermoregulation).

In contrast to previous studies, we found that only 16% of the nests were in cavities or broken-topped trees and 80% were on mistletoe brooms or abandoned hawk nests. In western Oregon, most nests (81%) were in cavities and no nests were in mistletoe growth; 50% of the nests found in the Klamath Mountains of Oregon, an area of mixed coniferous forests, were on platforms (Forsman et al. 1984). In California, 80% of the nests were in cavities or broken-topped trees and 20% were on platforms of unknown origin (LaHaye 1988). In addition, we found that 89% of the mistletoe and hawk nests in the WNF were in trees <200 yr old. Of the 17 platform nests in the Klamath Mountains (Forsman et al. 1984), 9 were in old-growth trees, 7 were in trees 100–200 yr old, and 1 was in a tree 80 yr old. Because some of the nest sites in the WNF occur in younger stands that lack other nest structures (e.g., mistletoe), prior occupancy by goshawks appeared to be related to occupancy by Spotted Owls; this apparent relationship with Northern Goshawks has obvious management implications.

Use of open nest structures, such as abandoned hawk nests or tops of mistletoe clumps, appears to be more common in forests east of the Cascade crest than to the west (Forsman et al. 1984, this study). This regional difference may be related to constraints imposed by differing rainfall and moisture regimes in the two areas

(E. Forsman pers. comm.). In the WNF there is a gradient from moist fir/hemlock in the west to drier pine forests in the east (Franklin and Dyrness 1973). We found that cavity and broken-top nests were significantly closer to the Cascade crest than other nest types. The distribution of various nest types might therefore also be explained by differences in availability of nest types as a result of varying distributions of mistletoe and fire frequency.

The characteristics of Spotted Owl nest trees and nest sites in the WNF are a result of the fire and logging history of this region. We noted evidence of logging activity at 21% of the nest sites and 46% of the nest stands (Buchanan 1991). With two exceptions, these partial harvests occurred more than approximately 40 yr ago. These harvests removed healthy or larger trees and left any trees infected with mistletoe. This type of harvest simultaneously removed large trees that may have been suitable for nesting and also predisposed the young trees in the stand to mistletoe infestations (Buchanan 1991).

Prior to the onset of fire suppression in the WNF at the turn of the century, mixed coniferous forest communities were characterized by fire intervals of less than 50 yr (Cobb 1988). This frequent fire interval likely restricted the establishment of Grand Fir and resulted in landscapes dominated by fire resistant species such as Western Larch, Ponderosa Pine, and Douglas-fir (the latter species is fire resistant when mature). Research from other mixed coniferous forests indicates that Douglas-fir/Grand Fir forests have become more widely established in the current landscape only after relatively longer fire-free periods (e.g., Antos and Habeck 1981). Forests in some areas within the eastern Cascade Mountains province, because of their species composition, structural attributes, and fuel loads accumulated during the fire interval, are highly unstable and vulnerable to stand replacement fire (Kaufman 1990). Management plans must account for these forest landscape changes and the associated risk of catastrophic fire.

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# HOME RANGES OF ADULT AND JUVENILE EASTERN SCREECH-OWLS: SIZE, SEASONAL VARIATION AND EXTENT OF OVERLAP

JAMES R. BELTHOFF,[1] EARL J. SPARKS AND GARY RITCHISON
*Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475 U.S.A.*

ABSTRACT.—We monitored the home ranges of radio-tagged adult ($N = 10$) and juvenile ($N = 7$) Eastern Screech-Owls (*Otus asio*) and examined spatial relationships between paired males and females, adults and their young, and neighboring conspecifics. Adult owls occupied home ranges that averaged slightly under 50 ha in size. We detected no significant differences in home range size of adult males and females during either the breeding season or non-breeding season. The ranges of paired screech-owls overlapped less during the non-breeding season, perhaps reducing competition between members of the pair. While still occupying parental territories, juvenile owls had significantly larger home ranges during the second half of the nine-week pre-dispersal period, and juveniles wandered outside the ranges of their parents more often during this time. Home ranges of juveniles were generally larger following dispersal from parental territories. We found more overlap in ranges between neighboring individuals than reported for many species of owls. Shared areas were usually used more by one owl, with only occasional excursions by the other owl. Such behavior is consistent with the notion that Eastern Screech-Owls defend exclusive areas or territories throughout the year. Finally, adult screech-owls and their young remained in close proximity during most of the post-fledging period, suggesting that Eastern Screech-Owls do not divide their broods between parents.

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Extensión del territorio del Tecolote Nororiental (*Otus asio*) adulto y joven: tamaño, variación estacional y extensión del solapo entre territorios

EXTRACTO.—Hemos controlado las extensiones del territorio habitado por búhos *Otus asio* adultos ($N = 10$) y jóvenes ($N = 7$), los que para este efecto estuvieron radioequipados; y hemos examinado la relación de espacios habitados por parejas de ellos con los de sus crías, y con los de otros de su especie de zonas vecinas. Los búhos adultos ocuparon territorios que promediaron ligeramente en menos de 50 ha de extensión. No hemos detectado significativas diferencias entre la extensión del territorio habitado por búhos adultos machos y la del territorio de las hembras, durante tanto el período reproductor como en el no reproductor. Durante la estación no reproductora hubo un menor solapo entre los territorios habitados por cada miembro de las parejas de estos búhos, tal vez así reduciendo la competencia entre ellos.

Durante la segunda mitad de las nueve semanas en que las crías aún no dejaban permanentemente el territorio paterno, ellas ocuparon territorios significativamente más extensos; en este período los jóvenes volaban más a menudo fuera del territorio de sus padres. Las extensiones habitadas por ellos generalmente se expandieron más después que dejaron permanentemente ese territorio.

Hemos encontrado más solapos, de los que se ha referido para muchas especies de búhos, entre los territorios de individuos vecinos. Áreas cohabitadas por dos individuos generalmente fueron usadas mayormente por uno de ellos, con sólo ocasionales excursiones hacia ese territorio hechas por el otro. Tal conducta es consistente con la idea que sostiene que el búho *O. asio* defiende áreas o territorios exclusivos durante el año. Finalmente, las parejas de búhos y sus crías permanecieron en territorios cercanos durante la mayoría del período que siguió al de haber dejado el nido; lo que sugiere que en estos *O. asio*, el número de las crías no se divide entre los progenitores.

[Traducción de Eudoxio Paredes-Ruiz]

Radiotelemetry studies have provided information on the movements, ranging behavior, and spatial relationships among many wide-ranging species of raptors. However, these studies reveal much variation among and within species in the size of ranges and their overlap with conspecifics, and factors contributing to this variation are not completely understood (e.g., Dunstan 1970, Nicholls and Warner 1972, Elody and Sloan 1985, Ganey and Balda 1989, Finck 1990). Existing evidence suggests that specific habitat requirements, population density, season of

[1] Present address: 3D/Environmental Services, Inc., 781 Neeb Road, Cincinnati, OH 45233 U.S.A.

the year, whether or not parents divide their broods, and various other factors could influence home range characteristics in birds (e.g., Southern 1970, Krebs 1971, Knapton and Krebs 1974, McLaughlin and Montgomerie 1985).

Eastern Screech-Owls (*Otus asio*) are relatively small, nocturnal predators that inhabit forested areas throughout much of eastern North America. Individuals generally do not migrate, and they apparently occupy the same areas throughout the year (VanCamp and Henny 1975). Limited information is available concerning the ranging behavior of and spatial relationships among Eastern Screech-Owls. Thus, the objectives of our study were to 1) determine the home range sizes of adult and juvenile Eastern Screech-Owls, 2) determine if owls vary the size of their home ranges during the year, 3) determine the extent to which ranges overlap, and 4) examine spatial relationships among adult screech-owls and their young during the post-fledging period.

## METHODS

We radiotracked 17 Eastern Screech-Owls between 30 May 1985 and 5 July 1986 in and near the 680-ha Central Kentucky Wildlife Management Area (CKWMA), located 17 km southeast of Richmond, Madison County, Kentucky. The management area consisted of small deciduous woodlots and thickets interspersed with cultivated fields and old fields (Belthoff 1987, Sparks 1990). Areas surrounding the CKWMA were mainly agricultural, but extensively wooded tracts occurred in nearby Jackson County.

We captured adult Eastern Screech-Owls either at artificial nest boxes and natural tree cavities or by luring them into mist nets by broadcasting bounce songs (Ritchison et al. 1988). Nests were located by following radio-tagged adults and by examining suitable tree cavities. We captured nestlings at nests several days prior to fledging. Adults and nestlings were equipped with radiotransmitters (Wildlife Materials, Inc., Carbondale, IL) and banded with U.S. Fish and Wildlife Service aluminum bands. Transmitters (4–5 g) were attached backpack-style with woven nylon cord (Smith and Gilbert 1981), and the transmitter plus harness generally weighed less than 6 g.

We determined the locations of owls by triangulating with receivers (TRX-24, Wildlife Materials, Inc. or TR-2, Telonics Inc., Mesa, AZ) and handheld two-element yagi antennas. Two recorders at separate stations and in radio contact with one another took simultaneous readings. Tracking periods usually began at or shortly after sunset and ranged from 2–4 hr in duration. We conducted all tracking between 1800–0400 H. Average locational error in all habitat types and at different times during the study averaged ±1 degree (Sparks 1990). We calculated home range areas with the TELEM program (Koeln 1980) using the minimum convex polygon method. In doing so, the outermost 5% of locations (i.e., those farthest from the mean center of activity) were deleted to avoid overestimating home range sizes (Burt 1943). We typically located individual owls at 20–30-min intervals during tracking periods. Because a 20-min interval was presumably sufficient for owls to cover their entire home ranges, we considered successive locations biologically independent (Lair 1987).

We determined home range sizes of adult Eastern Screech-Owls for two distinct biological time periods: breeding (1 March to 31 July) and non-breeding (1 August to 28 February). Home range sizes of juveniles were also determined for two biological periods: pre-dispersal (defined here as the period beginning the day young owls left nest cavities and ending the day young permanently left the parental home range) and post-dispersal. Juvenile screech-owls in central Kentucky typically leave the nest cavity during the third week in May, and they disperse from natal home ranges (i.e., those ranges used prior to dispersal from parental home ranges) in mid-July (see Belthoff and Ritchison 1989, 1990a). The post-dispersal period began the day after a juvenile dispersed from its parental home range and continued until the juvenile died or its radiotransmitter could no longer be located.

To examine spatial relationships among adult screech-owls and their young, we radiotagged all individuals in two families (both adults and three juveniles in each family). We determined the locations of each family member in a sequential fashion. For each sequence, the location of each family member was plotted on a map according to Universal Transverse Mercator (UTM) coordinates. We then calculated distances between adult males and females and each of their young.

Using a compensating polar planimeter, we measured areas within the home range that an individual owl shared with conspecifics. We also determined the number of locations of each owl in both overlapping and non-overlapping areas. We performed Chi-square tests to examine the frequency of use of shared versus non-shared areas (as determined by number of locations). The expected numbers of locations in shared and unshared areas were determined by multiplying the total number of locations in an individual's range by the proportion of that range that was shared and unshared, respectively. We used analysis of variance (ANOVA) to perform multiple comparisons among means and, if significant effects were detected, performed post-hoc tests using the Student-Newman-Keuls procedure (SNK). We used Mann-Whitney $U$-tests and Wilcoxon signed-ranks tests when comparing only two means. We calculated Spearman rank correlation coefficients to examine the relationship between number of locations and home range size. All statistical tests were two-tailed, and we set rejection levels at $\alpha = 0.05$. Means and standard errors are reported as $\bar{x} \pm$ SE.

We obtained 3453 locations of radio-tagged Eastern Screech-Owls ($N = 10$ adults and 7 juveniles) during 340 hr of tracking over 88 nights. Most locations ($N = 2237$) were during the breeding/pre-dispersal period ($N = 10$ adults and 6 juveniles), with fewer locations ($N = 1216$) obtained during the non-breeding/post-dispersal period ($N = 6$ adults and 4 juveniles). We radiotracked both members of three pairs during both the breeding and non-

Table 1. Home range size and extent of overlap with mate during the breeding period, non-breeding period, and overall period for mated pairs in five families of Eastern Screech-Owls ($N$ = number of telemetry locations).

| | | TIME PERIOD | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BREEDING | | | NON-BREEDING | | | OVERALL (ANNUAL) | | |
| FAMILY | SEX | SIZE (ha) | $N$ | % OVERLAP[a] | SIZE (ha) | $N$ | % OVERLAP[a] | SIZE (ha) | $N$ | % OVERLAP[a] |
| 1 | M | 60.6 | 184 | 84.8 | 25.8 | 70 | 45.6 | 68.4 | 254 | 75.2 |
| | F | 59.7 | 153 | 86.0 | 33.0 | 61 | 35.5 | 59.7 | 214 | 86.0 |
| 2 | M | 34.8 | 208 | 34.1 | 30.2 | 143 | 59.2 | 46.6 | 351 | 66.1 |
| | F | 11.9 | 186 | 100.0 | 44.1 | 261 | 40.6 | 48.4 | 447 | 69.7 |
| 3 | M | 29.3 | 44 | 46.1 | 35.6 | 79 | 41.8 | 38.6 | 123 | 49.8 |
| | F | 16.9 | 79 | 92.9 | 14.6 | 45 | 88.0 | 20.9 | 124 | 92.0 |
| 4[b] | M | 36.7 | 208 | 81.8 | 33.3 | 82 | — | 57.0 | 290 | — |
| | F | 35.4 | 210 | 84.9 | | — | | | — | |
| 5[c] | M | 15.9 | 57 | 32.4 | | — | | | — | |
| | F | 8.0 | 54 | 64.8 | | — | | | — | |

[a] Percentage of home range encompassed by mate's home range.
[b] Adult female killed several nights after young fledged.
[c] Tracked only during the breeding season.

breeding periods, while both members of two additional pairs were tracked only during the breeding period. Three juveniles were tracked during both the pre- and post-dispersal periods, and we tracked three additional juveniles only during the pre-dispersal period. We tracked one juvenile during the post-dispersal period only.

Initially, we detected a significant relationship (Spearman rank correlation, $r_s = 0.47$, $P < 0.024$) between the number of locations and home range size. However, this relationship was no longer significant ($r_s = 0.41$, $P = 0.058$) when we had at least 120 locations for a given owl. Therefore, we only report home range sizes for which we obtained at least 120 locations per owl (note: percent overlap was calculated no matter how many locations we obtained). For this reason, sample sizes reported within the results section may vary from the overall number of owls radiotracked.

## RESULTS

**Home Range Sizes.** Overall, adult Eastern Screech-Owls ($N = 6$) occupied home ranges that averaged 48.5 ± 5.9 ha in size (Table 1). We noted no significant difference (Mann-Whitney $U$-test, $U = 11.0$, $P = 0.859$) between mean overall home range size of males (52.6 ± 6.5 ha, $N = 4$) and females (43.0 ± 11.5 ha, $N = 2$). During the breeding season, adult Eastern Screech-Owls ($N = 6$) occupied home ranges that averaged 39.9 ± 7.5 ha in size. There was no significant difference (Mann-Whitney $U$-test, $U = 12.0$, $P = 0.663$) in mean home range size between males (44.1 ± 8.3, $N = 3$) and females (35.7 ± 13.8, $N = 3$) during the breeding period. During the non-breeding period, the two adult screech-owls for which we obtained >120 locations used home ranges that averaged 37.7 ± 6.9 ha in size (Table 1).

During the pre-dispersal period, juvenile Eastern Screech-Owls ($N = 6$) occupied home ranges that averaged 34.0 ± 6.3 ha in size (range 12.3–53.3 ha). Juvenile owls expanded their ranges as the post-fledging period progressed, such that they occupied significantly smaller home ranges (Wilcoxon signed-ranks test, $z = 2.201$, $P = 0.028$) during the first half of the pre-dispersal period (13.5 ± 2.0 ha) than during the second half (29.6 ± 4.9 ha). The home ranges of two juveniles during the post-dispersal period were 88.9 ha and 154.8 ha in size.

**Home Range Overlap.** The overall home ranges of three adult males overlapped the ranges of their mates by an average of 63.7 ± 7.4 percent, while the overall ranges of adult females ($N = 3$) overlapped those of their mates by an average of 82.6 ± 6.7 percent (Table 1). During the breeding season, adult males ($N = 5$) overlapped the ranges of their mates by an average of 55.8 ± 11.5 percent, and adult females ($N = 5$) overlapped the ranges of their mates by an average of 85.7 ± 5.9 percent. One female used a home range entirely within the boundaries of her mate's range. During the non-breeding period, adult males ($N = 3$) overlapped the ranges of their mates by an average of 48.8 ± 5.3 percent, and adult females ($N = 3$) overlapped the ranges of their mates by an average of 54.7 ± 16.7 percent.

We tracked no owls with adjacent ranges during the breeding season, but we did monitor two pairs with adjacent ranges during the non-breeding period. Neighboring males overlapped ranges by 40 and 56 percent, while neighboring females overlapped ranges by 26 and 51 percent. Among the neighboring males, one individual used the shared area significantly more than expected ($\chi^2 = 12.62$, $P < 0.001$). One neighboring male and female did not overlap their ranges, while another neighboring male and female overlapped by 62 and 57 percent, respectively.

Within two families, juvenile owls ($N = 3$ per family) overlapped the ranges of adults (male and female combined) by an average of 80 percent and 54 percent, respectively. Home ranges of juvenile owls overlapped those of adult males by an average of 78 and 61 percent ($N = 2$ families), and those of adult females by 82 and 47 percent. Adult males ($N = 2$) overlapped the ranges of juveniles ($N = 3$ per family) by an average of 60 and 34 percent, while the ranges of adult females ($N = 2$) overlapped ranges of these same juveniles by an average of 63 and 78 percent.

Prior to dispersal from parental ranges, siblings ($N = 3$ per family) in two families overlapped ranges by an average of 71.5 ± 5.8 percent and 65.0 ± 8.9 percent. Following dispersal, two juvenile screech-owls overlapped non-breeding ranges with three unrelated adult males by an average of 17.8 ± 4.2 percent. These same males overlapped the ranges of the two juveniles by an average of 65.7 ± 13.6 percent. The post-dispersal ranges of these two juveniles overlapped ranges with unrelated adult females ($N = 2$) by an average of 30.3 ± 12.4 percent, while the ranges of these females overlapped the juveniles' ranges by an average of 66.1 ± 26.0 percent. The post-dispersal home ranges of two juveniles also overlapped (by 28.8 and 50.1 percent, respectively), and both juveniles used the shared area equally.

**Distances Between Adults and Juveniles.** We monitored distances between adult males and females and their young in two families. We radio-tracked individuals in Family 1 on 14 nights during the period between 30 May (12 d post-fledging) and 17 July (60 d post-fledging). Juveniles in this family initiated dispersal 60, 63, and 65 d after fledging. We tracked individuals in Family 2 on 11 nights during the period from 6 June (23 d post-fledging) through 11 July (58 d post-fledging), and juveniles in this family initiated dispersal 56, 57, and 60 d after fledging.

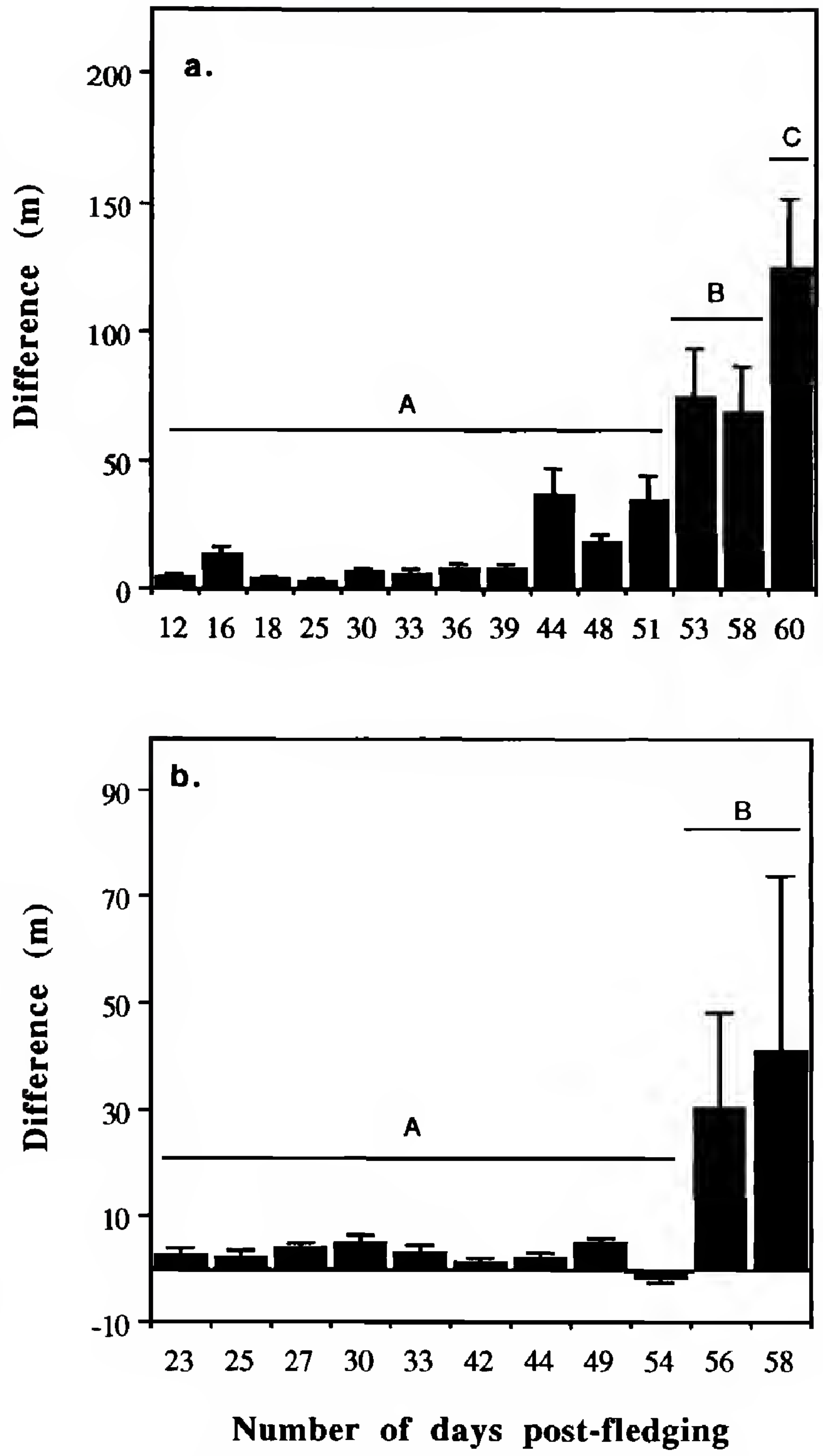


Figure 1. Nightly mean distance (±SE) that the adult male Eastern Screech-Owl was farther from juveniles than was the adult female in Family 1 (a) and Family 2 (b). Means with the same letter are not significantly different from each other.

Overall, juveniles ($N = 3$) in Family 1 were significantly closer (Wilcoxon signed-ranks test, $z = 5.597$, $P < 0.0001$) to the adult female ($\bar{x} = 45.0 \pm 4.6$ m, $N = 232$ locations) than to the adult male ($\bar{x} = 75.6 \pm 6.2$ m, $N = 278$ locations). No differences were found among siblings in their respective mean distances from either the adult female ($F = 0.52$, df $= 2, 229$, $P = 0.597$) or the adult male ($F = 1.04$, df $= 2, 275$, $P = 0.355$).

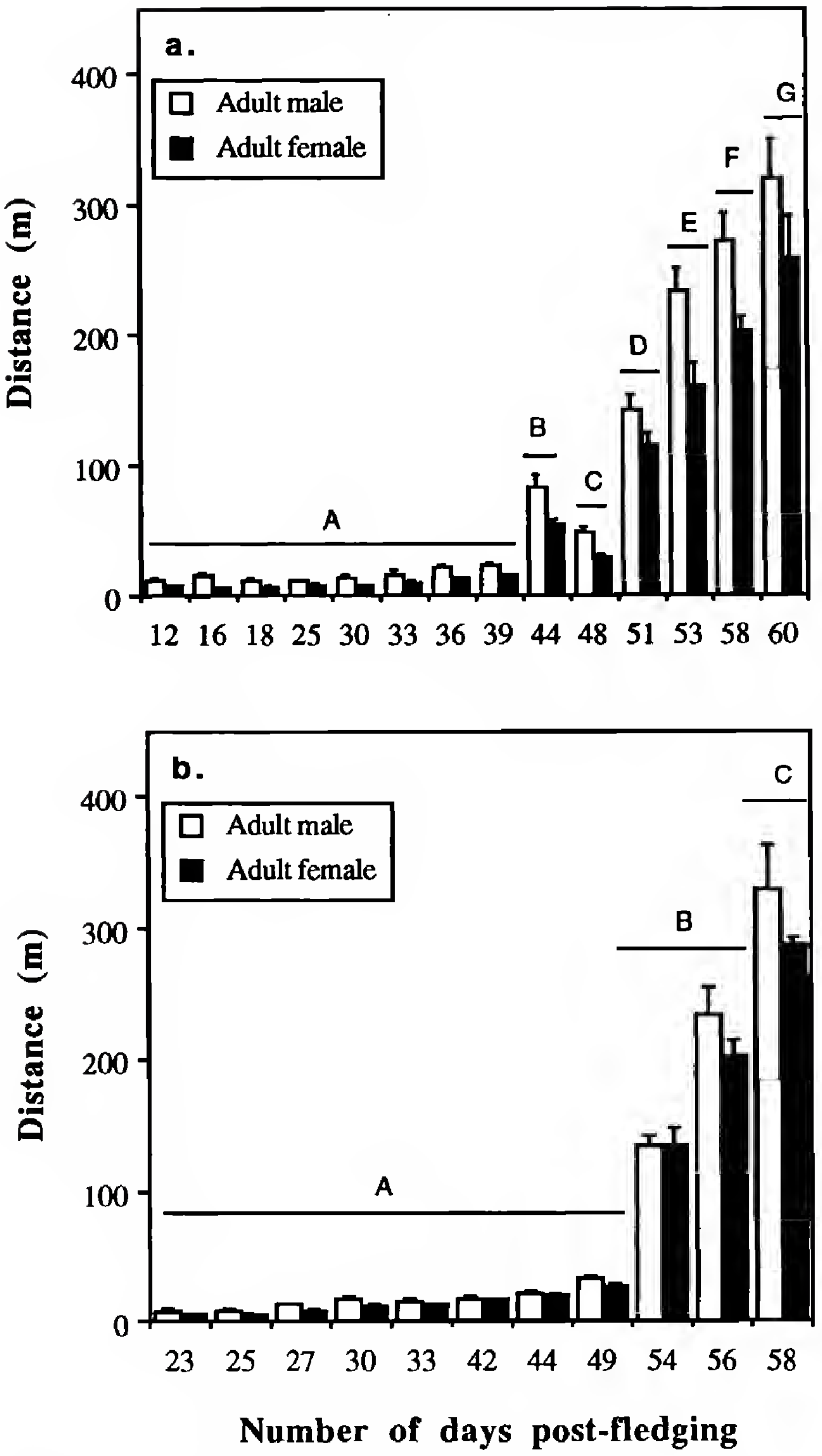


Figure 2. Nightly mean distance (±SE) between juvenile and adult Eastern Screech-Owls during the pre-dispersal period in Family 1 (a) and Family 2 (b). Means with the same letter are not significantly different from each other.

Examination of the differences in distance between juveniles and the adult male and female among nights revealed significant variation ($F$ = 15.33, df = 13, 218, $P$ < 0.0001), with juveniles significantly closer to the adult female during the last three tracking sessions (days 53, 58, and 60 post-fledging; SNK, $P$ < 0.05; Fig. 1a). The mean distance between juveniles and the adult female ($F$ = 106.3, df = 13, 218, $P$ < 0.0001) and male ($F$ = 106.4, df = 13, 264, $P$ < 0.0001) varied significantly among nights, with distances significantly greater from both the female and the male beginning on day 44 post-fledging (SNK, P < 0.05; Fig. 2a).

Overall, juvenile owls in Family 2 ($N$ = 3) were also located significantly closer (Wilcoxon signed-ranks test, $z$ = 2.720, $P$ = 0.006) to the adult female ($\bar{x}$ = 31.8 ± 3.5 m, $N$ = 240 locations) than to the adult male ($\bar{x}$ = 35.9 ± 3.8 m, $N$ = 240 locations). Siblings in Family 2 differed significantly in their respective mean distances from both the adult female ($F$ = 3.69, df = 2, 237, $P$ = 0.0263) and the adult male ($F$ = 4.52, df = 2, 237, $P$ = 0.012). Further analysis revealed that one juvenile (the same one in both cases) was located significantly farther (SNK, $P$ < 0.05) than its siblings from both the adult male and adult female.

Examination of the difference in distances between juveniles and the adult male and female among nights revealed significant variation ($F$ = 3.48, df = 10, 227, $P$ = 0.0003), with juveniles significantly closer to the adult female during the last two tracking sessions (days 56 and 58 post-fledging; SNK, $P$ < 0.05; Fig. 1b). The mean distance between juveniles and the adult female ($F$ = 228.2, df = 10, 227, $P$ < 0.0001) and adult male ($F$ = 300.4, df = 10, 227, $P$ < 0.0001) varied significantly among nights, with distances significantly greater from both the female and the male beginning on day 54 post-fledging (SNK, $P$ < 0.05; Fig. 2b).

## DISCUSSION

Eastern Screech-Owls occupy ranges that vary in size, with published estimates ranging from as small as 4 ha in Texas (Gehlbach 1986) to nearly 400 ha in Virginia (Hegdal and Colvin 1988). The home range sizes of individual Eastern Screech-Owls in our study were typically smaller than reported in previous studies using radiotelemetry. For example, Smith and Gilbert (1984) reported home range sizes of 130 ha for a female Eastern Screech-Owl tracked from January through June and 95 ha for a male tracked from May through June. Hegdal and Colvin (1988) reported a mean home range size of 134 ± 86.3 (SD) ha (range 54–388 ha) for 19 Eastern Screech-Owls. Although his methods were not reported, Gehlbach (1986) suggested that Eastern Screech-Owls in Texas occupied ranges that were smaller than observed in our study, averaging about 30 ha in rural areas and 4–6 ha in suburban areas.

Eastern Screech-Owls apparently prefer areas with varied habitats and abundant edge, i.e., ecotonal areas (Smith and Gilbert 1984). Woods, orchards, and

field-pasture are used more frequently than urban areas (Lynch and Smith 1984, Smith and Gilbert 1984) and cropland (Hegdal and Colvin 1988). Thus, one factor contributing to larger screech-owl home ranges in Connecticut and Virginia may have been the presence of large areas of poor quality habitats. While 39.3% of the Connecticut study area consisted of lawns (Smith and Gilbert 1984) and 23.2% of the Virginia study area was cropland (Hegdal and Colvin 1988), our study area in Kentucky contained no lawn habitat, and no screech-owl home range contained more than 4.5% cropland (Sparks 1990).

High population densities are another potential factor limiting the size of home ranges in owls. Male Flammulated Owls (*Otus flammeolus*) may expand their ranges when adjacent territories are vacant (Reynolds and Linkhart 1987). Similarly, Clark (1975) suggested that surrounding territories might serve to compress territories of Short-eared Owls (*Asio flammeus*). The density of screech-owls on our study area was relatively high (Belthoff and Ritchison 1990b), and this could have contributed to smaller home ranges. In fact, following the disappearance of one territorial male, one neighboring male in our study area expanded its range into the vacated area (unpubl. data).

The availability of prey is another factor that potentially influences home range size in owls, and negative correlations between prey availability and home range size have been either observed or suggested for many species (e.g., Clark 1975, Petersen 1979, Elody and Sloan 1985, Palmer 1986, Ganey and Balda 1989). If availability or relative abundance of prey decreases, as might be the case during the non-breeding period when screech-owls rely more on small mammals and less on invertebrates (Ritchison and Cavanagh 1992), owls may respond by increasing the size of their range (cf. Myers et al. 1979). However, the ranges of adult screech-owls in the present study did not increase in size during the non-breeding period. Therefore, it is possible that prey availability did not decrease during winter on our study area, or that owls compensated in some other manner; e.g., they reduced areas of overlap with mates (see below).

We noted no differences in either overall or seasonal range sizes between adult male and female Eastern Screech-Owls. Fuller (1979) reported that both a male Barred Owl (*Strix varia*) and a male Great Horned Owl (*Bubo virginianus*) had much larger ranges than their respective mates during the incubation/early brooding period (see also Petersen 1979). During incubation, female Eastern Screech-Owls spend most of their time in the nest cavity and are fed by their mates (Gehlbach 1986). We obtained few locations during the incubation period (typically from mid-March to mid-April in central Kentucky), but detailed observations during this time period (approximately 30 d; Gehlbach 1986, pers. observ.) would probably reveal that the relatively sedentary females have smaller ranges than actively hunting males.

Juvenile screech-owls occupied significantly larger home ranges during the latter half of the pre-dispersal period. Increases in the size of home ranges may be the result of both increased mobility on the part of juveniles and their decreased dependence on the adults (Southern et al. 1954, Fuller 1979). Our results and those of Belthoff and Ritchison (1990c) suggest that juvenile Eastern Screech-Owls become independent of adults around six or seven weeks after leaving the nest (i.e., well into the second half of the eight- or nine-week period between fledging and the initiation of dispersal). Young screech-owls also exhibit increased locomotor activity in the weeks just prior to initiating dispersal (Ritchison et al. 1992), which may have contributed to the larger ranges observed during the second half of the pre-dispersal period.

The ranges of paired screech-owls overlapped more extensively during the breeding season (see also Craig et al. 1988, Ganey and Balda 1989). At least two factors may have contributed to this increased overlap: 1) males and females spent more time together during the period just prior to nesting (perhaps to facilitate courtship and copulation or because of mate guarding by males) and 2) both males and females focused their activities around the nest site during the nesting period. Reduced overlap during the non-breeding period may reduce competition during a period of decreased prey availability.

In contrast to other owl species (e.g., Clark 1975, Nicholls and Fuller 1987, Reynolds and Linkhart 1987, Bull et al. 1988, but see Hayward et al. 1987), neighboring Eastern Screech-Owls overlapped ranges during the non-breeding season (see also Gilbert 1981). Gehlbach (1986:58) suggested that Eastern Screech-Owl ranges in suburban areas overlapped and, further, that "males defend only the cavities and areas in the immediate vicinity." Areas of overlap in the present study were typically used more than expected by only one individual. This suggests

that only occasional excursions were made into the shared area by the other individual (i.e., the neighbor). Raptors may reduce competition by using shared areas at different times with priority of access determined by dominance status (Fuller 1979). If boundaries of total ranges are not regularly patrolled, excursions by neighbors into ranges of dominant conspecifics could occur.

Our data concerning spatial relationships among adult screech-owls and their offspring are useful in assessing the likelihood of brood division. In many species with biparental care, parents apparently divide their brood after young leave the nest (McLaughlin and Montgomerie 1985). Soon after fledging, for example, young Flammulated Owls divide into subgroups, each of which is tended by a different parent (Linkhart and Reynolds 1987). Flammulated Owl subgroups disperse from the nest in different directions and apparently do not come into contact during the remainder of the fledgling dependency period (Linkhart and Reynolds 1987). In contrast, our results corroborate those of Belthoff and Ritchison (1990c) and suggest that adult Eastern Screech-Owls do not divide their broods. Brood division may provide several benefits, including minimizing losses to predators, increased foraging efficiency, and helping young learn to forage (McLaughlin and Montgomerie 1985). However, there may also be advantages in not dividing broods. Young may benefit from remaining together if they learn foraging skills from each other (e.g., Edwards 1989a, 1989b). In addition, young in a subgroup being cared for by only one parent may not survive if that parent is killed. On the other hand, a brood that remains together will still be cared for by the surviving adult (and young are perhaps more likely to survive) following the death of one of the parents. Zaias and Breitwisch (1989) noted that researchers should be cautious of accepting brood division as the general rule because convincing demonstration of brood division requires detailed observations. Clearly, additional studies of fledgling care in birds are needed.

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# PARENTAL CARE, NESTLING BEHAVIORS AND NESTLING INTERACTIONS IN A MISSISSIPPI KITE (*Ictinia mississippiensis*) NEST

EUGENE S. BOTELHO[1] AND ANTONIO L. GENNARO
*Department of Biology, Eastern New Mexico University, Station #33, Portales, NM 88130 U.S.A.*

PATRICIA C. ARROWOOD
*Department of Biology, P.O. Box 30001/Dept. 3AF, New Mexico State University, Las Cruces, NM 88003 U.S.A.*

ABSTRACT.—We conducted an in-depth study from hatching to fledging of one Mississippi Kite (*Ictinia mississippiensis*) nest with two nestlings. Both parents cared for the young throughout the nestling period. The male delivered food directly to the nestlings and fed more pieces of food to the nestlings than did the female. The total number of pieces of food eaten by each nestling was similar across the nestling period. Of the many nestling behaviors observed six are discussed here, including allopreening, biting nest material, setting the nest, working the nest, and preening. Aggression occurred between the nestlings, with the younger nestling (B) initiating close to as many aggressive encounters as the older nestling (A). These data suggest that the Mississippi Kite's patterns of parental care and nestling behavior may be quite different from that of other raptors.

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Cuidados paternales, conducta e interacción de las crías en el nido del Milano Migratorio (*Ictinia mississippiensis*)

EXTRACTO.—Hemos conducido un exhaustivo estudio de un nido de Milano Migratorio con dos crías, desde la incubación hasta que los pollos dejaron el nido. Ambos padres dieron sus cuidados durante todo el período en que las crías estaban en el nido. El macho les trajo la comida directamente y les dio más porciones de lo que proporcionó la hembra. Los totales de las porciones que comió cada uno de estos milanos jóvenes, durante el período de su permanencia en el nido, fueron similares. De los muchos aspectos de conducta observados en éstos, seis se discuten en este estudio: Limpieza y arreglo de las plumas tanto mutuo como individual; agresión del uno al otro; picoteo al material del nido; arreglo del material del nido; ajuste y construcción del nido. Agresiones ocurrieron entre ellos: siendo el pollo más joven (B) el iniciador de casi tantos encuentros agresivos como los del pollo mayor (A). Estos datos sugieren que en milanos de la especie *I. mississippiensis*, los patrones tanto de los cuidados paternales como los de la conducta de las crías pueden ser muy diferentes a los de otras raptoras.

[Traducción de Eudoxio Paredes-Ruiz]

Mississippi Kites (*Ictinia mississippiensis*) breed in North America from North Carolina west to Arizona and New Mexico. They winter as far south as Paraguay (Blake 1949) and Argentina (Eisenmann 1963) and have been observed migrating through Guatemala (Parker 1977). Individuals arrive on the breeding grounds already mated in early May and depart for the wintering grounds in late August or early September (Bent 1937).

We observed nestling and adult behaviors at one Mississippi Kite nest during the 1988 breeding season (Botelho 1989). In this paper we 1) quantify adult patterns of nestling care, 2) quantify and compare the behaviors of the two nestlings, and 3) compare these data to that from other raptors.

## STUDY AREA AND METHODS

The nest was on a 45-ha golf course in a residential area of Clovis, Curry Co., New Mexico. The course was sparsely wooded, with the dominant trees (and nest tree) being Siberian elm (*Ulmus pumila*). The nest was 5 m above the ground in a fork of two branches about 2 m from the main trunk. Observations were made from a platform blind 6 m from and level with the nest.

The parental behaviors quantified included the amount of time each parent spent on the nest feeding young and the number of pieces of food each parent delivered to each nestling. Each time a parent delivered and fed a portion of prey to the young this was scored as a piece of food.

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[1] Present address: Department of Biology, P.O. Box 30001/ Dept. 3AF, New Mexico State University, Las Cruces, NM 88003 U.S.A.

Because the adults of this species are sexually dimorphic, the male was easily distinguished from the female by his smaller size and lighter head. Also, the female had white feathers on her breast which formed streaks not present on the male. The sex of the nestlings could not be determined, but their difference in age was apparent throughout the nestling period.

Six of the most common nestling behaviors are described here (see Botelho 1989 for a discussion of 11 other nestling behaviors recorded), including allopreening between nestlings, aggression (one nestling bites at the other), biting nest material (biting the twigs of nest rim), preening, setting nest material (placing and manipulating delivered material into the nest), and working nest material (adjusting nest material). Parental feeding duration was timed with a digital stopwatch; for all other behaviors the number of times these were exhibited was recorded. All activities at the nest were also recorded on VHS tape and later analyzed to supplement the data collected on site. Observations and video taping typically began at 0500 H and ended at 1800 H daily from the day of first hatch (3 July) to the last day either of the young was present in the nest (12 August). Observations sometimes ended early in the afternoon because of lightning storms. A total of 41 d in whole or part were spent observing the nest, for a direct observation duration of 420 hr over the course of the nestling period.

## Results and Discussion

The nestlings hatched 2 d apart. Data collection for each nestling began with its first day of life. The older nestling (A) left the nest during the fifth week after hatching while the younger (B) did so in its sixth week. Nestling A, however, returned to the nest periodically, especially when the parents brought food to nestling B still at the nest.

Prey consisted primarily of Apache Cicada (*Tibicen sayi*); a few other insects of similar size were also fed. Parents fed nestlings pieces of food of relatively equal size which were torn from the prey. During the first two weeks, parents chewed pieces of food before presenting them to the nestlings; strings of saliva were often visible as parents fed these chewed pieces to the young. Nestlings were, on occasion, fed pieces of toads (*Bufo* sp.).

Parental care was exhibited by both adults throughout the nestling period. The duration of time parents spent feeding nestlings increased for both nestlings from week 1 to week 2, with a decrease thereafter (Fig. 1). The decrease seemed to be due to the reduced need for parents to tear up and chew food before presenting it to the nestlings.

Prey was seldom transferred from the male to the female, and each parent fed the nestlings separately when both were at the nest. The number of pieces of food presented to each nestling by each parent is summarized in Table 1. The male provided more pieces of food to both nestlings than did the female. Each parent presented a similar weekly average number of pieces of food to each nestling. The differences that did exist were generally less than the weekly averages between the male and female. Nestling A received more pieces of food from the male during its first 3 weeks of the 6-week nestling period, whereas nestling B received more pieces from the male during its last 3 weeks of the nestling period. The number of pieces of food delivered to each of the young was most similar between adults during the first week of each nestling's life. The male greatly exceeded the female in the number of pieces of food delivered to each nestling during weeks 3 and 4. Thereafter (weeks 5 and 6), less of a difference was apparent, although the number of pieces of food fed by the male and female to nestling B differed more than to nestling A.

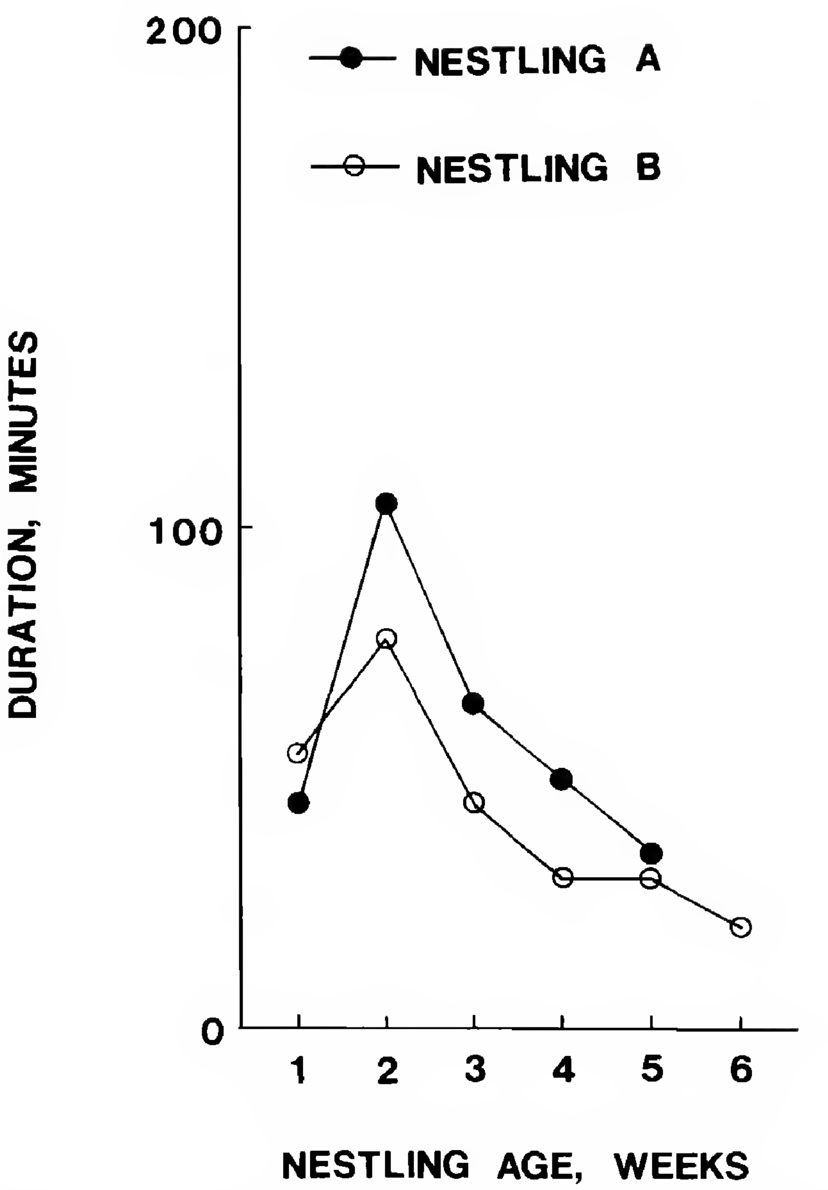


Figure 1. Parental feeding duration at a nest of Mississippi Kites according to nestling age.

Nestling behaviors are summarized in Figures 2–

Table 1. The number of pieces of food given to each nestling by each parent Mississippi Kite in New Mexico.

| WEEK[a] | PARENT | NESTLING A | NESTLING B |
|---|---|---|---|
| 1 | Male | 363 | 151 |
| | Female | 360 | 160 |
| 2 | Male | 400 | 335 |
| | Female | 442 | 458 |
| 3 | Male | 703 | 686 |
| | Female | 235 | 315 |
| 4 | Male | 506 | 692 |
| | Female | 315 | 290 |
| 5 | Male | 177 | 404 |
| | Female | 124 | 179 |
| 6 | Male | 12 | 139 |
| | Female | 34 | 12 |
| $\bar{x}$/week (±SD) | | | |
| | Male | 360.2 ± 221.8 | 401.2 ± 224.1 |
| | Female | 251.7 ± 139.0 | 235.7 ± 140.0 |
| Total, weeks 1–6 | | | |
| | Male | 2161 | 2407 |
| | Female | 1510 | 1414 |

[a] Since an age difference of two days existed between nestlings, data are arranged for each chick's week 1, 2, etc.

4. Preening was common. Preening duration increased with nestling age but decreased during the last 1–2 wks of the nestling period (Fig. 2). We observed allopreening between the nestlings, although it was a relatively uncommon behavior (Fig. 3). Allopreening was most often initiated by nestling A (five of seven events). Nestlings typically allopreened each other's head.

Nest setting was rarely exhibited during the initial weeks of the nestling period but increased during weeks 4 and 5 (Fig. 3). Nest setting did not occur during week 6 probably due to the fledging of nestling A and the movement of nestling B from the nest to the nearby branches.

Nest working consisted of nestlings biting and manipulating green nest material already present in the nest cup. Nestlings were typically crouched, or preparing to crouch, in the nest while exhibiting this behavior. Nest working was observed during weeks 3–5 but did not occur in weeks 1 and 6 (Fig. 3). Nestlings were too young to exhibit this behavior during week 1 and in week 6 spent most of their time either away from the nest tree (nestling A) or in branches (nestling B).

Nest biting consisted of nestlings biting nest twigs which made up the nest rim. Nest biting was the most frequently exhibited behavior. It occurred with increasing frequency up to week 4 after which the frequency sharply decreased (Fig. 3).

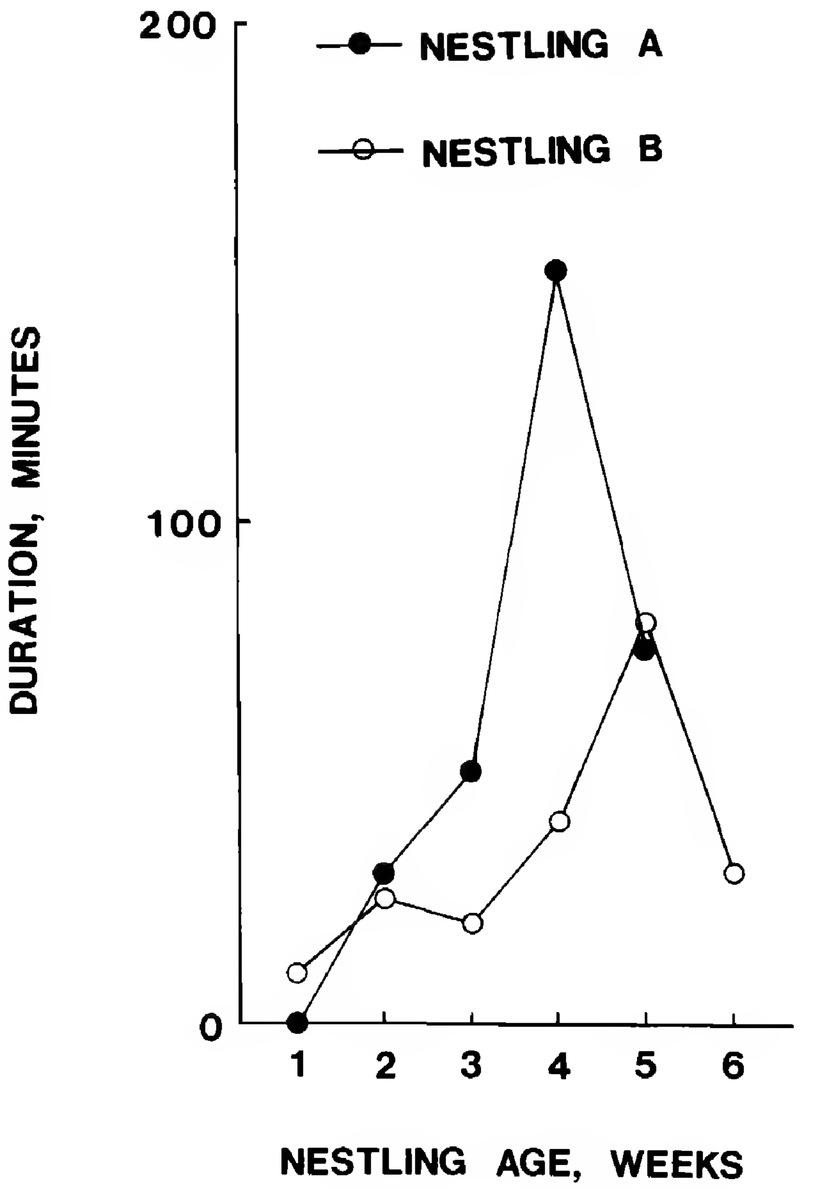


Figure 2. Preening durations by nestling Mississippi Kites according to age.

Aggressive acts consisted of nestlings lunging at each other with open beaks. Nestlings struck each other in the head region only; no other body areas were struck. Aggression was exhibited sporadically throughout the nestling period, but occurred most frequently during week 1 (Fig. 4). The incidence subsided during week 2; this was also the week with the greatest duration of parental feeding (Fig. 1). Aggression was low in week 3, but increased again during weeks 4 and 5. Nestling A behaved aggressively toward nestling B 20 times while nestling B behaved aggressively toward nestling A 16 times.

The number of pieces of food delivered to both nestlings was the highest during the middle (week 3) of the nestling period, although the parental feeding duration was greatest for both chicks in their

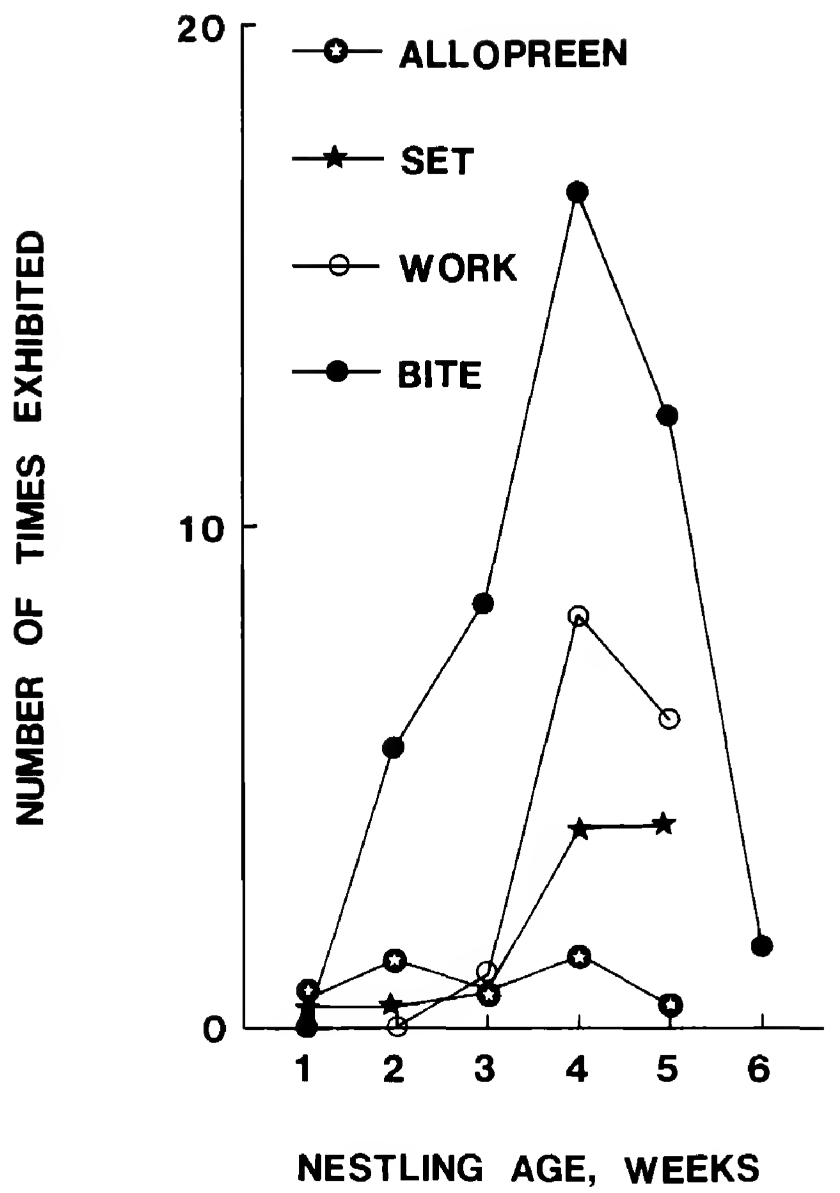


Figure 3. Number of times allopreening, nest setting, nest working, and nest biting were observed according to age of nestling Mississippi Kites (points represent average values for both nestlings).

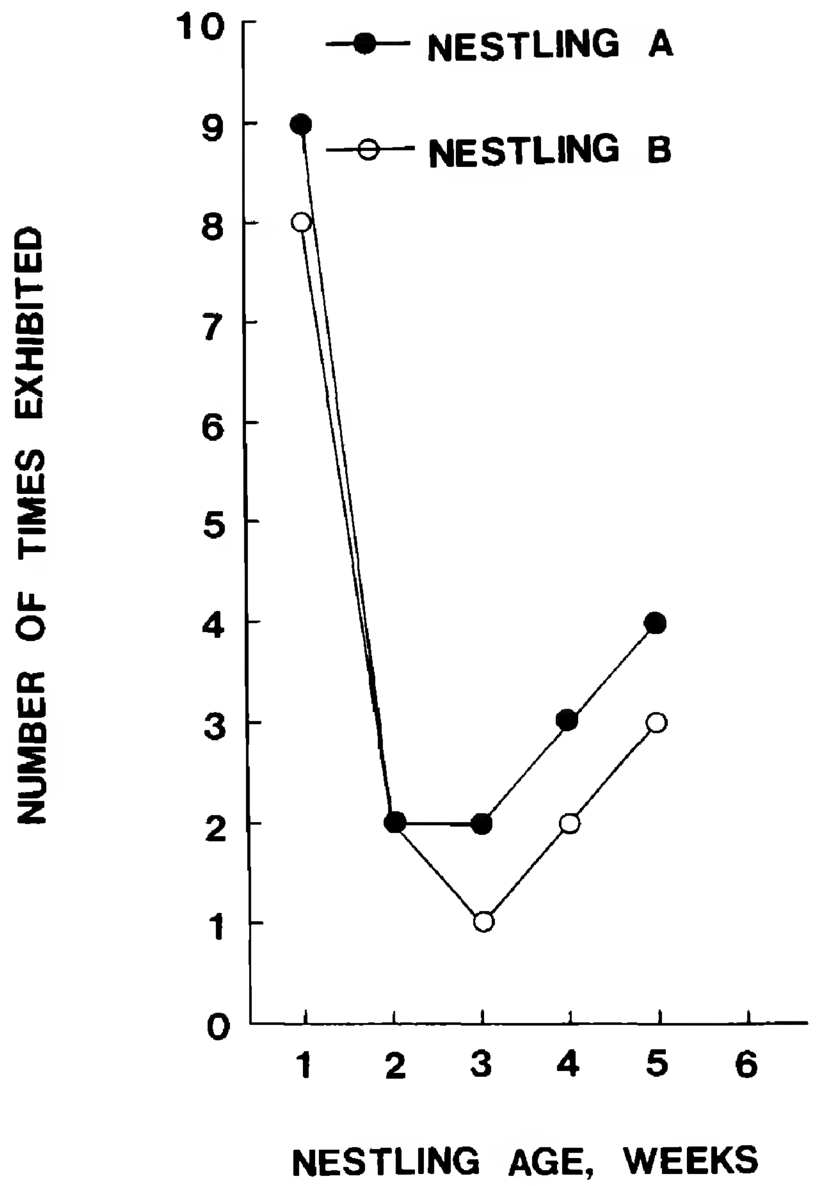


Figure 4. Number of times aggressive behavior between nestling Mississippi Kites was observed, according to nestling age.

second week. Another Mississippi Kite nest at the same study site, that contained a single nestling, showed a peak in duration of parental feeding during week 1 of a 5-week nestling period (pieces of food eaten by nestlings were not quantified in this study; Airth-Kindree 1988). The pattern of a mid-period peak in parental feeding has been noted in other raptors. Golden Eagle (*Aquila chrysaetos*) nestlings experienced an increase in feeding during weeks 7 through 9 of a 10-week nestling period (Collopy 1984). Nestling Sparrowhawks (*Accipiter nisus*) peaked in food consumption in weeks 2 and 3 of a 4-week nestling period (Newton 1978).

The behavior of the male seemed crucial to the survival of the nestlings. Prey brought to the nest and fed to the young by the male made it less necessary for the female to leave the nest to forage, at least initially. Male inattentiveness in a Golden Eagle nest forced the female to leave the nest, forage for herself and later abandon the nestlings (Collopy 1984). Heavy summer rains and wind, typical during this study, can threaten nestling survival, especially when the nestlings are unattended by parents (see also Newton 1978, Moss 1979).

The sibling aggression observed in this study did not appear to establish an absolute dominance scenario common in many other birds, including large raptors (Poole 1979, Drummond et al. 1986, Wechsler 1988). Aggressive acts delivered by nestling A to B were reciprocated during each week even though there was a size difference between nestlings. The nestlings were fed similar amounts of food during the study. Food was not aggressively taken from one nestling by the other nor did nestling A interfere with parental feeding of nestling B. Our impression was that food was readily available to the adults during this study.

Allopreening has rarely been reported between raptor nestlings or fledglings (see Varland et al. 1991). Allopreening has also been noted among American Kestrel (*Falco sparverius*) fledglings (Sherrod 1983). Although the incidence was very low among the Mississippi Kite nestlings, its occurrence demonstrates more inter-sibling affiliative behavior than is characteristic of many raptors.

Upon depositing nest material on the perimeter of the nest, parents either flew from the nest or remained but made no attempt to incorporate the material into the nest cup. Nestlings manipulated new (green) vegetation into place in the nest cup after the parent left the material. Nest working and nest setting by nestlings have not been reported in other raptors. Nestlings, thus, were not just passive inhabitants of the nest but instead actively participated in nest maintenance.

The behaviors observed in this study were made through extensive observations. A study of this nature allowed us to note important, and rarely exhibited, behaviors (i.e., aggression, allopreening, nest setting, nest working). Although only one nest was examined during this study, some of the same behaviors (including male participation in feeding and preening) have been seen also in another nest of Mississippi Kites in the same area (Airth-Kindree 1988). Some of the behaviors we observed are sufficiently different from other raptors to raise interesting questions about the reproductive biology of kites of the genus *Ictinia*.

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# CRYOPRESERVATION OF AMERICAN KESTREL SEMEN WITH DIMETHYLSULFOXIDE

George F. Gee, C.A. Morrell, J.C. Franson[1] and O.H. Pattee
*Patuxent Wildlife Research Center, Laurel, MD 20708 U.S.A.*

Abstract.—Semen samples from 15 male American Kestrels (*Falco sparverius*) were frozen in dimethyl sulfoxide (DMSO). The semen was thawed 1–14 mo later and used to inseminate six females during three breeding seasons. Kestrels inseminated with thawed semen containing 4% DMSO produced only infertile eggs ($N$ = 14). Kestrels inseminated with thawed semen containing 6%, 8%, or 10% DMSO produced fertile eggs ($N$ = 14) and live chicks ($N$ = 6). Progressive motility of spermatozoa in thawed semen containing 10% DMSO was less (44 ± 6%) than in thawed semen containing 6% (62 ± 10%) or 8% (61 ± 1%) DMSO.

Criopreservación del semen del Halcón Cernícalo (*Falco sparverius*) con dimetilsulfóxido

Extracto.—Muestras de semen de 15 Halcones Cernícalo (*F. sparverius*) fueron congeladas en dimetilsulfóxido (DMSO). El semen fue descongelado entre 1 y 14 meses más tarde, y fue usado para inseminar seis halcones hembras durante tres períodos reproductivos. Las que fueron inseminadas con semen descongelado que contenía 4% de DMSO, solamente produjeron huevos estériles ($N$ = 14); las otras que fueron inseminadas con semen descongelado que contenía 6%, 8% o 10% de DMSO produjeron huevos fértiles ($N$ = 14) y pollos vivos ($N$ = 6). La movilidad de espermatozoides en semen descongelado que contenía 10% DMSO fue menor (44 ± 6%) que en semen descongelado que contenía 6% (62 ± 10%) u 8% (61 ± 1%) DMSO.

[Traducción de Eudoxio Paredes-Ruiz]

Recent advances make it possible to collect and preserve sperm and to inseminate many mammals and some birds (Seager et al. 1978, Gee 1983). When genetic diversity is lost, frozen gene pools (gamete or embryo banks) can reestablish genetic diversity in captive or small native populations. The frozen material contains genetic variation of the original population from which the materials were collected. Methods are now available for the cryopreservation of semen from chickens (*Gallus domesticus*; Sexton 1980), Sandhill Cranes (*Grus canadensis*; Gee et al. 1985), and Aleutian Canada Geese (*Branta canadensis leucoparia*; Gee and Sexton 1990).

Many species of raptors are listed as endangered (Cade and Temple 1977, King 1978) and captive propagation and release programs have been successful with some (Weaver and Cade 1983). Raptors can pose special challenges to captive propagators: small captive populations, incompatible and infertile pairs, and small semen volumes. Artificial insemination has been used successfully with many of these species (Gee and Temple 1978, Gee 1983, Weaver and Cade 1983). Wildlife managers need a reliable method for the preservation of semen to support these captive raptor propagation programs. Two raptor studies revealed some success in long-term preservation of Peregrine Falcon (*Falco peregrinus*; Parks et al. 1986) and American Kestrel (*F. sparverius*; Brock 1986) semen. Neither experimenter used dimethyl sulfoxide (DMSO) as the cryoprotectant. DMSO is superior to other cryoprotectants because it does not have to be removed from the semen prior to insemination (Sexton 1980, Gee et al. 1985). We have investigated the effect of cryopreservation on avian semen (Gee et al. 1985, Gee and Sexton 1990) and wanted to apply these techniques to raptors. In this study we attempted to determine the best DMSO concentration for cryopreservation of American Kestrel semen.

## Materials and Methods

Semen was collected on Monday, Wednesday, and Friday from 15 American Kestrel males during the normal breeding season in 1983–85 and stored frozen for 1–14 mo prior to use. Nine males were housed with females in 3 m wide, 15 m long, and 1.8 m high outdoor wire-mesh-covered pens. Males of the other six pairs were housed individually in similar pens with their females in the adjacent pens. Pens contained two shelter boxes, three hang-

[1] Present address: National Wildlife Health Research Center, 6006 Schroeder Road, Madison, WI 53711 U.S.A.

Table 1. Protocol for collection and cryopreservation of American Kestrel semen used in insemination trials.[a]

| | Semen Dilution | | |
|---|---|---|---|
| Trial | When Collected[b] | After Adding DMSO[c] | DMSO% (v/v) |
| 1 | 1:1 | 1:2 | 4 |
| 2 | 1:3 | 1:7 | 4 and 6 |
| 3 | 1:0.5 | 1:1 | 6, 8 and 10 |

[a] Semen was collected at ambient temperatures from −12–+27°C, held at 1–5°C for <2 hr, equilibrated with DMSO for 10–15 min and frozen. Semen was frozen at 1°C/min from +5°–−20°C, at 50°C/min from −20°–−80°C, and at −160°C/min from −80°–−196°C. Semen was thawed in an ice bath at 0.5°C for 3 min. In each of three trials, 140 μl of semen was inseminated.

[b] BPSE (Sexton 1977) at 7.4 pH, 330 mmol/kg.

[c] DMSO diluted with semen extender before diluting semen.

ing perches, a water bowl, a feeding platform and a nest box (Porter and Wiemeyer 1970). Birds were fed Nebraska® Bird of Prey Diet (Central Nebraska Packing, Inc., North Platte, NE U.S.A.)[2] and day-old chickens on alternate days. The feeding platform and water bowl were cleaned daily. Birds were kept in these pens the year round. New individuals from our other colonies were introduced in February to replace birds injured or lost the previous year. After laying an infertile clutch of eggs, some of the single females (male in adjacent pen) were inseminated with thawed semen. Females were inseminated on Monday, Wednesday, and Friday and immediately after an egg was laid. Insemination following oviposition compensated for the days when an egg was present in the oviduct. Birds were not inseminated when an egg was present in the oviduct. For insemination, we chose females whose lay dates corresponded to times when adequate frozen semen pools were available.

We collected semen throughout the reproductive season from all males and, in all cases except those noted, diluted the semen as we collected it with Beltsville Poultry Semen Extender (BPSE; Sexton 1977). We modified the massage technique of Bird and Rehder (1981) to collect semen from several birds in the same container. We removed semen from the ventral lip of the cloaca with a small catheter with a Luer tip attached to a 1 ml syringe. A propipette, attached to the opposite end of the syringe, provided suction. The syringe barrel of the suction device was also used for measuring and diluting the semen.

An assistant held the kestrel in the palm of her hand while the operator stroked the abdomen with one hand and the base of the tail and ventral lip of the cloaca with the other hand. In the final step the operator forced the tail back with the heel of the hand and expressed the semen from the dorsal lip of the cloaca.

[2] Mention of this or any other commercial product does not constitute endorsement by the U.S. Government.

Semen was transferred to 1 ml collecting vials and placed in small (3 ml) test tubes that were partially submerged in an ice bath <5°C in the field, in transit, and upon return to the laboratory. Semen samples (5–10 μl) that contained motile sperm and little contamination were pooled. In seven pooled, undiluted semen samples, we measured osmolality and pH with a Wescor 5100B Vapor Pressure Indicator Osmometer and a Lazur® PHM-146 Micro pH Electrode according to manufacturer's instructions. In all semen samples we used progressive motility of sperm (Sexton and Gee 1978), degree of contamination, and concentration score (Gee and Temple 1978) to evaluate semen quality. We studied sperm morphology and obtained cell measurements in fresh semen (one drop of semen and one drop of stain under a 22 mm square coverslip) with a 1% eosin B or phloxine B stain, and in air dried smears stained with 1% phloxine B and 10% nigrosin stain, or in Bouin's fluid with eosin-nigrosin stain (Sigma HT10 1-32, Sigma Chemical Co., St. Louis, MO 63178 U.S.A.). We examined both the live wet mount and the air dried smear under a light microscope at 400×.

Sperm survival (progressive motility) in BPSE (7.4 pH, 330 mOs) and three variations (7.8 pH, 310 mOs; 7.0 pH, 310 mOs; and 7.5 pH, 280 mOs) were used to determine the most suitable semen extender for semen collection and cryopreservation. We estimated progressive motility (spermatozoa moving in a forward motion) on a scale from 0–100%. Samples for preservation were held in an ice bath (<5°C) for up to 2 hr before freezing. Semen samples were held in DMSO (4%, 6%, 8% or 10%; v/v) for 10–15 min before freezing. A 0.2 ml sample of diluted semen, equivalent to 3–4 ejaculates, was then placed in labeled plastic straws (0.5 ml Frenchstraw [Fiche de gontrola]; Edwards Agri-Sales Inc., Baraboo, WI 53913 U.S.A.), heat sealed, attached to a prenumbered semen cane, and frozen (Gee and Sexton 1979, Gee et al. 1985; Table 1). Frozen semen was transported in a portable liquid nitrogen tank and thawed for 3 min in an ice bath (0.5°C) immediately before use (Table 1). After thawing, we removed the semen from the straw with a small catheter and 1 ml syringe. The cloaca of the selected female American Kestrel was everted, exposing an everted vagina, the syringe was inserted 1–2 cm into the oviduct, the cloaca was allowed to return to the relaxed position with the syringe in place, and the semen was deposited. We everted the cloaca by holding the bird against our bodies. We applied a slow steady pressure to the abdomen while pressing the area around the cloaca with the thumbs and index fingers of both hands A 5–10 μl sample of the thawed semen was set aside at room temperature for semen quality evaluation (within 1 hr).

Fertility of eggs from birds inseminated with thawed semen and progressive motility of that semen were used to evaluate the effectiveness of cryopreservation. To determine fertility, eggs were candled at 14 d. Clear eggs were opened and examined for early death under a 7× dissecting microscope, and eggs with live embryos were returned to the nest.

Although the small data set makes statistical analysis tentative, we used the $t$-test to test the significance of differences between two sample means (Steel and Torrie 1960). We used the one-way classification analysis of vari-

ance where appropriate (Steel and Torrie 1960). Percentage values were sign transformed before analysis.

## RESULTS AND DISCUSSION

The six female American Kestrels inseminated with thawed semen containing DMSO as cryoprotectant produced 48 eggs, 14 (29%) of which were fertile (Table 2). Of the 14 eggs incubated by females, 4 were broken and 6 of 10 eggs (60%) hatched. No fertile eggs were obtained from kestrels inseminated with thawed semen containing 4% DMSO (14 eggs). Six of 17 eggs (35%), 4 of 10 eggs (40%), and 4 of 7 eggs (57%) were fertile from kestrels inseminated with thawed semen containing 6%, 8% and 10% DMSO, respectively. Differences in fertility between kestrels inseminated with semen containing 6%, 8%, or 10% DMSO were not significant.

At least one-half of the kestrel sperm in seven freshly collected semen samples were progressively motile for up to 96 hr after storage at $<5°C$ in BPSE at 7.0, 7.5, and 7.8 pH. No differences in motility were evident between extender pHs, but sperm concentration decreased in all samples. Therefore, the apparently high survival rate (50% motile cells) could have been an artifact if sperm were dying and disintegrating, as suggested by the decrease in concentration.

We were unable to determine percent live spermatozoa in thawed kestrel semen using conventional live-dead stains (Gee 1983). Stains such as eosin-nigrosin did not stain dead kestrel spermatozoa. In Peregrine Falcon semen, the opposite condition exists, eosin stains both live and dead cells (Hoolihan and Burnham 1985). Thawed semen contained fewer ($57 \pm 12\%$) progressively motile cells, a measure of sperm vitality (Smyth 1968), than semen prior to freezing ($77 \pm 9\%$; Fig. 1) with equivalent DMSO concentrations ($P \leq 0.001$). Also, thawed semen with 10% DMSO contained fewer progressively motile spermatozoa ($44 \pm 6\%$) than thawed semen with 6% ($62 \pm 10\%$) or 8% ($61 \pm 1\%$) DMSO ($P \leq 0.05$).

Individual ejaculates from American Kestrels are small (Bird and Lague 1977, Brock 1986), 10–20 $\mu l$ in our study. The sperm concentration also is lower (Bird and Lague 1977) than in other birds (Gee 1983). Our American Kestrel semen yielded the lowest sperm score, 2 or less (Gee and Temple 1978), of any healthy bird examined in our laboratory. Most clean American Kestrel semen appears clear to slightly yellow. In addition to spermatozoa, kestrel semen usually contains clear, round bodies of various sizes, other debris, and, occasionally, a few squamous cells and erythrocytes.

Table 2. Reproductive success of female American Kestrels artificially inseminated with frozen and thawed semen containing 4, 6, 8, or 10% dimethylsulfoxide as the cryoprotectant in 1983–85.

| | DIMETHYLSULFOXIDE | | | |
|---|---|---|---|---|
| | 4% | 6% | 8% | 10% |
| No. of kestrels | 3 | 4 | 2 | 2 |
| Eggs | 14 | 17 | 10 | 7 |
| Fertile eggs | 0 | 6[a] | 4[b] | 4[b] |
| Infertile eggs | 14 | 11 | 6 | 3 |
| Eggs hatched | 0 | 2 | 2 | 2 |

[a] Two eggs destroyed by kestrels.
[b] Egg destroyed by kestrels.

On smears stained in phloxine B (1%)-nigrosin (10%), the heads of kestrel spermatozoa varied in size and shape, but most (50%) were spherical (4–8 $\mu m$) in diameter. Sperm tails were of varying lengths (9–14 $\mu m$, one of 50 $\mu m$). The end of the tail was often broken, coiled or looped, even in the fresh semen sample. However, our method for making semen slides seemed to damage the spermatozoa. Our kestrel semen contained larger cells than those reported by Bird and Lague (1977; 2 $\mu m \times 4$ $\mu m$) and by Brock (1986; 3.4 $\mu m \times 2.7$ $\mu m$). We found and measured three classes of spermatozoa in the fixed semen smears: round (8.2 $\mu m \times 6.1$ $\mu m$), elliptical (4.4 $\mu m \times 3.4$ $\mu m$), and elongate (6.3 $\mu m \times 2.5$ $\mu m$). Brock (1986) described the elliptical cell on slides stained with 1% glutaraldehyde in phosphate-buffered saline solution and stained with fast green FCF. It was the most common cell we observed (50% of the cells). However, the acrosomal cap and midpiece observed with the fast green technique were larger than those we observed on slides stained with phloxine.

We examined hundreds of slides and hundreds of cells per slide at a variety of light and filter settings and with phase contrast in an attempt to determine the morphology of the spermatozoa in fresh semen. Fresh semen stained with phloxine B (1%) produced the most consistent motility estimate because we could see the cells better against the pink background color than in a clear solution. Immotile cells, similar to the elliptical and round cells on prepared slides, were found in fresh semen stained with phloxine B. We

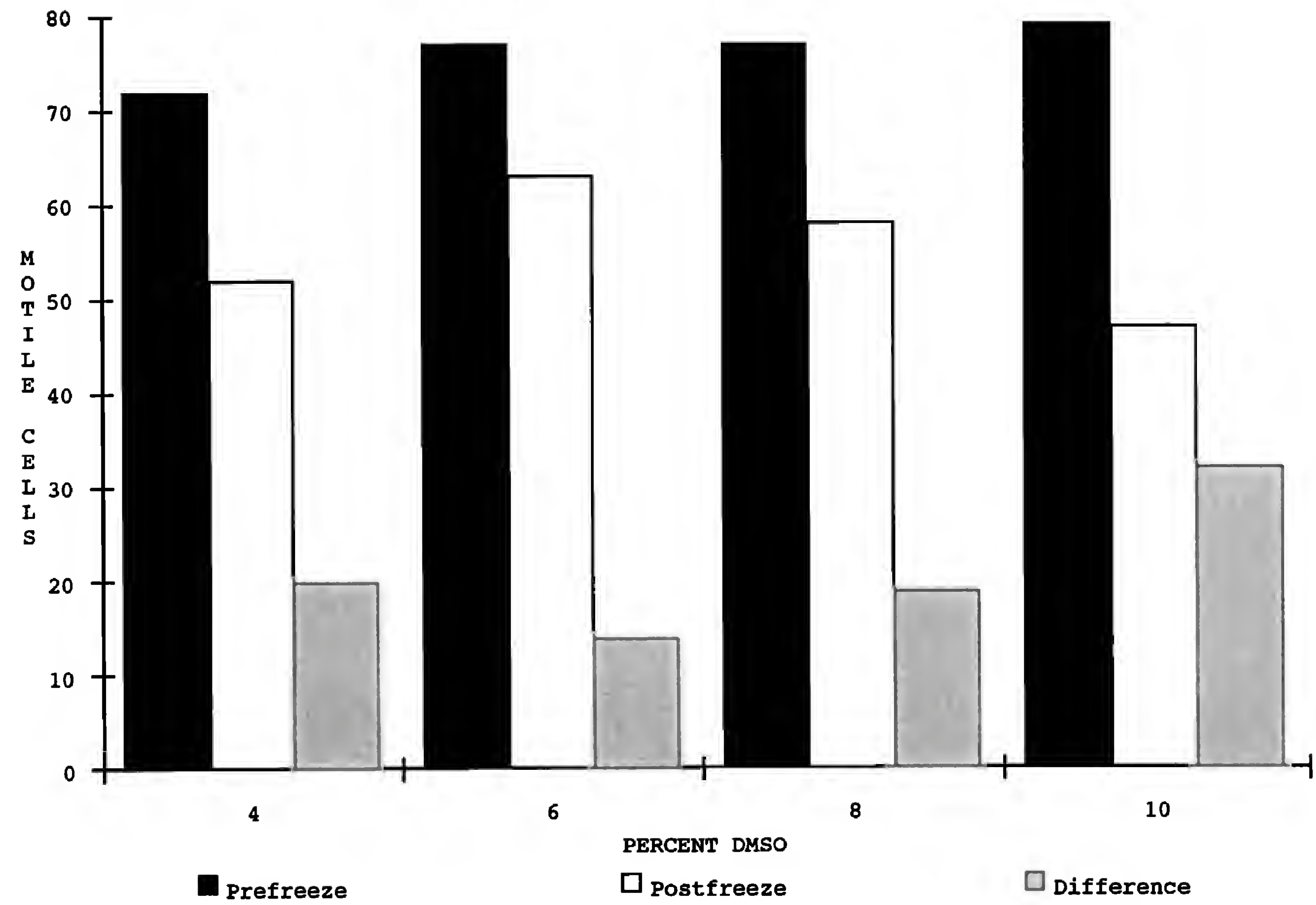


Figure 1. Progressive motility of kestrel semen cryopreserved in dimethylsulfoxide.

observed about 1% of these spherical cells lose their tails and, on occasion (about a dozen), burst, leaving only the red-stained acrosomal cap and midpiece. Our progressive motility estimates to evaluate treatments may have been in error because of the tendency of dead cells to burst. This may also explain why, in our evaluation of semen extenders, we observed a decrease in concentration after storage for 24 hr.

We found the spermatozoa of the American Kestrel unusual when compared to semen collected from other birds, in terms of shape, motility, cell number and live-dead staining characteristics. The round cell in kestrel semen resembled the droplet cell in crane semen (Gee and Temple 1978, Russman 1979). In all the semen examined for motility, we saw very few (4 or 5 per year) sauropsid cells, similar to those of Peregrine Falcons (scanning electron micrograph by W. Burnham pers. comm.) and in one case, a part of a sauropsid cell buried in the round cell. Sauropsid cells were rare but were always motile. In 281 species examined by McFarlane (1971) all avian sperm heads were cylindrical and tapering at each end. The gradual change from sauropsid to the elongated, markedly helical shape in passerines and other ultrastructural changes indicate phylogenetic relationships (McFarlane 1971). The true shape of kestrel spermatozoa, whether round as seen in fixed semen (fast green or phloxine slides) or sauropsid as seen on occasion in fresh semen, was not determined.

Semen with spherical sperm ranging from 2–14 $\mu$m long and 1–18 $\mu$m wide and propelled by a single 5-50 $\mu$m long tail produced fertile eggs. Although we tried to test for semen quality, the spermatozoa and semen characteristics of the American Kestrel restricted our study. We found the comparison of fertile egg production of limited usefulness because of the small number of birds and eggs in the study.

Fertile eggs and chicks can be produced by kestrels inseminated with thawed semen cryopreserved in

extender containing DMSO. Kestrels inseminated with thawed semen containing 6%, 8%, or 10% DMSO as the cryoprotectant produced fertile eggs and chicks. A 4% DMSO concentration (v/v) in the semen provided inadequate cryopreservation and 10% DMSO resulted in lower progressive motility than 6% or 8% DMSO.

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# LOSS OF COOPER'S HAWK NESTING HABITAT TO SUBURBAN DEVELOPMENT: INADEQUATE PROTECTION FOR A STATE-ENDANGERED SPECIES

THOMAS BOSAKOWSKI[1]
*Department of Biological Sciences, Rutgers University, Newark, NJ 07102 U.S.A.*

ROBERT SPEISER
*13 Beam Place, Haledon, NJ 07508 U.S.A.*

DWIGHT G. SMITH
*Biology Department, Southern Connecticut State University, New Haven, CT 06515 U.S.A.*

LAWRENCE J. NILES
*New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Tuckahoe Management Area, Tuckahoe, NJ 08250 U.S.A.*

ABSTRACT.—We examined land use and human disturbance factors around 18 nest sites of Cooper's Hawk (*Accipiter cooperii*) in northern New Jersey. Aerial photo analysis of 12 nest sites revealed that surrounding habitats were comprised largely of forest (73.3–99.1%) with very little suburban habitat (0–6.7%). Evidence of new housing construction was observed at 6 nests impacting 33.3% of the known Cooper's Hawk nest sites in this area. A review of current New Jersey laws revealed that very little protection was afforded this species despite its "state-endangered species" status. In order to ensure complete protection, we recommend that any nest site occurring in a wilderness area (>200 ha) be protected permanently against any habitat alterations within a 0.6 km radius around nest sites.

Gavilán Pechirrojo Mayor (*Accipiter cooperii*) pierde su hábitat para anidar debido al desarrollo suburbano: protección inadecuada en el estado, para una especie en peligro de extinción

EXTRACTO.—Se examinó el uso del terreno y la presencia humana, como factores perturbadores en el rededor de 18 sitios donde anida el gavilán de la especie *Accipiter cooperii*, en el norte de Nueva Jersey. Análisis aerofotográficos de 12 de estos sitios de reproducción, revelaron que hábitats de alrededor fueron en su mayoría conformados de floresta (73.3–99.1%) con muy poco hábitat suburbano (0–6.7%). Se observaron las evidencias del efecto de la construcción de nuevas casas en seis nidos, cuyo impacto afectó el 33.3% del total de sitios de anidar conocidos en el área para este estudio. Una revisión de las leyes de actualidad que rigen este aspecto en Nueva Jersey, reveló que muy poca protección se ha venido dando a esta especie, pese a su estatus de "especie en peligro de extinctión en el estado." A fin de asegurar protección completa, se recomienda que cualquier sitio de anidar del *A. cooperii* que surja en áreas silvestres (>200 ha), sea protegido permanentemente contra cualquier alteración del hábitat dentro de un radio de 0.6 km alrededor del sitio.

[Traducción de Eudoxio Paredes-Ruiz]

The Cooper's Hawk (*Accipiter cooperii*) has been classified as an endangered species in New Jersey since 1974. Although not a federally endangered species, it was "Blue Listed" by the National Audubon Society in 1972–81, relisted as a Species of Special Concern in 1982 and returned to their Blue List in 1986 (Tate 1981, 1986). Although many reports suggest that this accipiter is "doing better" in the eastern part of North America (Tate 1986), several northeastern states continue to list the Cooper's Hawk as a "Species of Special Concern" (Mosher 1989). Concern for its status began in the early 1970s when migration data showed a steady decline in numbers following widespread use of DDT (see Snyder et al. 1973). However, recent migration data

[1] Present address: Utah Division of Wildlife Resources, Fisheries Experiment Station, 1465 West 200 North, Logan, UT 84321 U.S.A.

suggest that the population may be partially recovering (Mosher 1989).

One consequence of urbanization in the Northeast has been the loss of significant forest area for breeding birds (Robbins et al. 1989). Since Cooper's Hawks may utilize traditional nest sites for several years (Bent 1937, Reynolds 1983, this study), the loss of even a few sites may jeopardize local population stability. We describe encroachment at several nest sites, consider the lack of protection afforded to these sensitive areas and make recommendations for improving legal protection of nest sites and habitat in New Jersey.

## STUDY AREA AND METHODS

The study was conducted in the highlands of northern New Jersey, an area of rolling, granitic hills. Dominant relief extends from northeast to southwest and elevations vary from 507 m to nearly sea level. The region is heavily forested and sporadically populated with suburban and occasional rural housing. Wilderness tracts are more extensive in northern and central sections. Forests are mostly a mosaic of mature and submature, second growth oak (*Quercus*) dominated stands. Old growth stands are rare and <10 ha in area. Small plantations of conifers (50-60 yr old) occur in some areas. A more detailed description of the highlands study area has been previously reported (Bosakowski 1990, Bosakowski et al. 1989, Speiser and Bosakowski 1988).

Forest raptor populations in northern New Jersey and southeastern New York have been monitored since 1979 (Speiser and Bosakowski 1987, 1988, Bosakowski et al. 1987, 1989, Bosakowski 1990). Most nests were found by methodically searching woodlands on foot. Particular attention was given to areas where adults were seen during the breeding season, or where protesting calls were heard. We also checked nests and nest site areas discovered during the fall and winter to ascertain occupancy. Two nests were spotted while driving through the study area during routine field work.

Aerial photographs (1:8000) were obtained for 12 nest sites which occurred in the Pequannock Watershed drainage (Sussex, Passaic, and Morris counties). Habitat areas were calculated from 300 m radius plots around the nest tree following the methods outlined in Bosakowski (1990). Distance from the nest tree to the nearest house was measured to the nearest mm.

For the purpose of this paper, a nest site is defined as the area immediately surrounding an active nest and alternate nests (if any) and geographically distinct from other active or previously used nests (at least 1.2 km distant—the minimum nearest-neighbor distance in Bosakowski 1990). Wilderness was broadly defined as "an uncultivated, uninhabited region." This paper is specific with regard to New Jersey endangered species laws, zoning regulations, and authority of local planning commissions. Furthermore, it is also specific to the known habitat requirements of Cooper's Hawks in New Jersey (Bosakowski et al. 1992) and may not be applicable to other regions where habitat selection may differ.

## RESULTS

From 1979-90 we located a total of 18 Cooper's Hawk nests during the breeding raptor surveys. All 18 nest trees were still standing by 1990, but nest site encroachment via clear-cutting associated with residential development has occurred at six (33.3%) of these sites. Below we describe the type and extent of encroachment on these impacted Cooper's Hawk nesting sites.

**Case 1.** A nest site located in Morris County was occupied for ≥3 yr (1985-87). In spring 1988, a suburban housing project was started within 100 m of the nest tree, following which the site was abandoned. Subsequent enlargement of the clear-cut area associated with the housing development now extends to within 50 m of the nest tree and flagging that marks future development extends beneath the old nest tree.

**Case 2.** A nest located in Sussex County was found in 1989. A female was seen on 17 March 1989 about 20 m from a completed nest in a Scotch pine (*Pinus sylvestris*). Multiple nests in this area suggest a traditional nesting territory, used for at least 2-3 yr. Both the older and the active nests were located <30 m from a new road constructed for residential development. On 17 April 1989 the female was incubating on the nest most distant from the old development. At that time, a 0.15 ha lot had been recently cleared to within 40 m of the nest. TB contacted the town planning commission and warned the developer of the state-endangered species nesting on his property. The developer indicated that construction on the lot containing the active nest was not scheduled for several months, but he would try to minimize disturbance. Several weeks later TB returned to find workmen using a chainsaw and woodchipper about 100 m from the nest, but the female continued incubating despite the noise and activity of workers at both lots. Two young fledged from this nest, possibly because the adults were reluctant to abandon the nest after commencing incubation prior to the construction activities. In the 1990 season, the nesting stand was still intact and a female responded vocally to tape-recorded calls once. However, no subsequent nesting activity was observed within 0.5 km of the area despite several intensive searches.

Table 1. Aerial photographic analysis of 12 Cooper's Hawk nest sites in northern New Jersey. Percent habitat areas were determined for a 0.3 km radius around each nest site.

| | % Forested | % Suburban | Nearest House (km) |
|---|---|---|---|
| | 99.1 | 0 | 2.06 |
| | 94.2 | 0 | 0.45 |
| | 93.8 | 2.9 | 0.20 |
| | 93.1 | 1.8 | 0.14 |
| | 92.4 | 1.3 | 0.27 |
| | 91.1 | 0 | 0.70 |
| | 90.4 | 0 | 0.48 |
| | 84.4 | 0 | 0.69 |
| | 82.6 | 0 | 0.34 |
| | 78.8 | 2.7 | 0.31 |
| | 75.6 | 1.6 | 0.28 |
| | 73.3 | 6.7 | 0.11 |
| Mean | 87.4 | 1.4 | 0.50 |
| SD | 8.25 | 2.00 | 0.526 |

**Cases 3 through 5.** Three nest sites active in 1989 in Passaic and Morris counties are now threatened with expanded housing development in already established developments located 100–500 m from the nests. The three nest sites were located on city watershed property but bordered extensive woodlands which were not protected. The nest sites were also near woods roads (2–30 m) and nesting adults were frequently exposed to illegal all-terrain vehicle traffic by neighborhood adolescents. None of these nests were reused in 1990, and no evidence of adults or new nests were found.

**Case 6.** A new nest was found in 1990 on the edge of a large Morris County park in New Jersey, but a second nest 100 m away suggested that this pair had nested in the territory for at least one or two additional seasons. The active nest was located 140 m from a main road and 120 m behind a house constructed within the past year. A half-completed housing development is located about 300 m from the nest. The nest was successful in 1990, but the suitability of the site may be altered after the development is occupied.

**Habitat Analysis.** Analysis of aerial plots for 12 nest sites revealed an average of 87.4% forested habitat and only 1.4% suburban habitat (Table 1). This trend for low suburban development was also consistent with the distance to the nearest house which averaged 0.5 km.

## Discussion

**The Negative Impacts of Development.** Development and associated clear-cutting have encroached on 33.3% of the 18 Cooper's Hawk nest sites that we found in extensively forested habitats in the northern New Jersey highlands. In a review of northeastern accipiters, Mosher (1989) noted that there were only 25 historical confirmed nestings of Cooper's Hawks in New Jersey (prior to 1988). Thus, our results probably represent a significant proportion of encroachment on the current statewide population of nesting Cooper's Hawks. The encroachments may be attributed to inadequacy of current regulatory protection of Cooper's Hawk habitat, inadequate protection on public lands, unknown effects of disturbance and forest fragmentation, and difficulty in evaluating the potential impact of habitat loss on nesting Cooper's Hawks.

Land ownership is an important factor in conservation of the nest sites: 10 of the 18 nests were located on city watershed property, 3 were on state parks or state forests, 2 were on county parklands, 2 were on private property, and 1 was located within a woodland on a U.S. military base. Cooper's Hawks may nest more frequently on private lands than our results indicate since fewer searches were conducted in these areas. Additionally, nests on restricted property may not be noticed or go unreported, hence are vulnerable to development and excessive disturbance.

During the breeding season, we found that Cooper's Hawks are usually secretive and generally avoid human disturbance, although two exceptional nests were placed within 50 m of a busy road or within 110 m of occupied houses. However, these nests were placed on the edge of large tracts of undisturbed woodland. Hennessy (1978) and Lee (1981) also found that Cooper's Hawks could tolerate some disturbance, especially when traditional nest sites are occupied. Thus, the occasional finding of an active nest near houses cannot logically be used as proof that the species can survive well in suburbia.

Suburban developments may also impact local Cooper's Hawk populations by reducing total forested area within the traditional nesting territory and contributing to forest fragmentation (Lovejoy et al. 1986, Robbins et al. 1989). The observation that active nests were surrounded by an average of 87.4% forested habitat and only 1.4% suburban habitat suggests a critical need for contiguous forest areas for nesting. With the nearest house averaging 0.5 km

from the nest, these Cooper's Hawks are selecting an average circular habitat area of 1.0 km in diameter without a single house. The impact of new developments near Cooper's Hawk breeding habitat will produce forest fragmentation effects which lower breeding populations of interior bird species (Robbins et al. 1989), the principal prey of Cooper's Hawk in our area (Bosakowski et al. 1992).

Local forest fragmentation may also reduce availability of "floaters" that can replace lost mates or occupy unoccupied territories. In saturated Cooper's Hawk populations, mate replacement can occur rapidly after mortality of either male or female (as many as three different males in one nesting) and a brood can be raised successfully (Bent 1937). Offspring have even been raised by unrelated parents when mates were sequentially replaced (Bent 1937). Therefore, large wilderness areas need to be set aside to prevent the effects of isolation as forests in the Northeast are increasingly cut into smaller isolated fragments. Small disjunct populations are more vulnerable to extirpation than a large thriving population network (Wilcove 1987).

Disturbance factors associated with development, including firewood cutting, hikers, dogs, children playing, recreational vehicles, and associated noise also increase the likelihood of flushing the female from a nest resulting in mobbing by crows, crow predation on eggs/young, or attracting other predators (e.g., Great Horned Owl, *Bubo virginianus*; Hennessy 1978, Craighead and Mindell 1981, Lee 1981). Development may also augment local increases in raccoon (*Procyon lotor*) and opossum (*Didelphis virginiana*) populations; both species are occasional predators on eggs and young of raptors.

**Inadequacy of Current Habitat Protection.** In New Jersey, as in most of the Northeast, all permit applications are reviewed by town planning and zoning commissions and/or town wetland commissions which must approve the regulated activity proposals prior to initiation of any construction. Membership on these review commissions varies with the township and consequently the wildlife "expertise" of each review board varies considerably; certainly very few, if any, boards can be expected to include professional ornithologists. Therefore, most review boards depend on input from local naturalists (D.G. Smith pers. observation) or agency biologists (J. Lincer pers. comm.) who may advise the board during hearings. In any event, these permits have only limited influence in preserving nesting habitat. Township boards can request developers to consider the pattern of development but they cannot legally stop a developer from building on a property that follows zoning conditions.

State agencies such as the New Jersey Bureau of Freshwater Wetlands can prevent destruction of a habitat only if an active Cooper's Hawk nest occurs within one mile (1.6 km) of a wetland. Such wetlands can then be designated as having "exceptional resource value" and the normal "50 foot wetland buffer zone" can be extended to "150 feet" surrounding the wetland. However, all other upland habitat, excepting the actual nest tree, will still remain unprotected. Given the large home range requirements of Cooper's Hawks (see review by Reynolds 1983), this extra "100 foot of buffer zone" is not likely to help preserve a habitat for future nesting.

Even if the nest or foraging habitat is within the jurisdiction of the state regulatory agencies and the land is protected from development, the agencies do not protect against disturbance. Neither state nor local agencies can protect nest sites from infrequent, but regular, disturbances from children, adults, dogs and other inevitable intrusions from development in adjacent habitats (e.g., three of the nests were adjacent to borders or very close to private land where development was occurring). In addition, only state parks and national wildlife refuges in New Jersey are safe from periodic timber sales which are permitted in state forests.

In New Jersey, environmental impact statement (EIS) surveys do not provide adequate provisions to protect or even locate nesting Cooper's Hawks: 1) they can be performed at any time of the year—not likely that Cooper's Hawks will be nesting, 2) they require only simple qualitative listing of species present and no validation of survey required by state wildlife agency, 3) training of personnel is variable—only an experienced *Accipiter* or Cooper's Hawk researcher can ensure that nests are not present (see Rosenfield et al. 1985, 1988), 4) no consideration is given to nearby disturbance factors—e.g., car traffic, firewood cutting, lawn mowers, recreational vehicles, children playing, general noise pollution, dogs and cats, 5) surveyed habitat could be suitable for Cooper's Hawk nesting, but not necessarily occupied the year of the survey. On this final point, it is obvious that development of a habitat suitability model could be extremely important to set aside existing forest habitat for Cooper's Hawk.

**Recommendations.** We propose that proper sur-

vey techniques (Rosenfield et al. 1985, 1988, Bosakowski 1990) during the breeding season should be mandatory on all EIS surveys that pertain to any development that extends into or adjacent to a forested wilderness area (>200 ha). Where nest sites are located, a radius of half the minimum nearest-neighbor distance (1.2 km) should receive complete protection from habitat alterations (0.6 km radius around nest sites). Reynolds (1983) selected half the mean nearest-neighbor distance to approximate territory size for Cooper's Hawks. Thus, our recommendation of half the minimum nearest-neighbor distance is liberal from a biological standpoint. Given the rapid and often unregulated development occurring in New Jersey and the rest of the Northeast, we urge that these restrictions be applied to safely ensure that nesting populations of Cooper's Hawks will survive in the Northeast in future decades.

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# SEX DIFFERENCES IN NESTING SITE ATTENDANCE BY PEREGRINE FALCONS (*Falco peregrinus brookei*)

PASCAL CARLIER
*Université Paul Sabatier, Centre de Recherche en Biologie du Comportement, CNRS—URA 664, 118, route de Narbonne, 31062 Toulouse cedex, France*

The Peregrine Falcon (*Falco peregrinus*) usually shows a strong fidelity to its nesting site. Nonmigratory peregrines may be observed near the nest at any time of the year. According to the sex of the bird and the developmental period of its young, there are variations in the time a site is attended (Nelson 1970, Carlier and Gallo 1989). The purpose of this paper is to report sex differences in parental attendance in the nesting areas throughout the breeding period.

## METHODS

Five peregrine pairs (*F. p. brookei*) were studied from courtship until fledging of their young in the region of Quercy, southwest of Massif Central, France. Observations totaled 525 hr, during 113 half days from 11 February to 28 June 1989. Observation bouts lasted either from daybreak until midday or from midday until dark, with each nesting area being studied at different times.

Sites where the nests were easily visible from at least 100 m away were chosen for observation. Most of the eyries were located on cliffs, three were in holes and two on ledges. All parents were adults at least 2 yr old, as indicated by their plumage.

Observations were made with a 20–60× telescope and 8× binoculars, using a continuous sampling method (Tacha et al. 1985). Behavior, movement and time notations were recorded on audio cassettes. Two areas were distinguished for each site: 1) the nest site, defined by the eyrie and its immediate surroundings, and 2) the nesting area, including the nest and the area around the nest that the pairs occupied.

Twelve developmental periods were distinguished during the breeding cycle: 1) courtship, 2) incubation, 3) pipped eggs, 4) early nestling period with young ≤10 d old, or 5) young between 10–20 d old, 6) late nestling period with young between 20–30 d old, or 7) young between 30–40 d old, 8) fledging period with young between 40–50 d old, or 9) young between 50–60 d old, or 10) young between 60–70 d old, or 11) young between 70–80 d old, or 12) young between 80–90 d old. If several observation segments occurred for the same site within a same period, they were pooled. A total of 55 observation segments were spent during the entire period.

## RESULTS

**Attendance in the Nesting Area by Females.** There was a significant difference between periods in the proportion of time the females attended the nesting areas (Kruskal-Wallis $H = 39.44$, df = 11, $P < 0.001$, $N = 55$; Fig. 1). Attendance was negatively correlated with developmental periods (Kendall Rank Correlation Coefficient Tau = $-0.641$, $Z = -6.911$, $P < 0.001$, $N = 55$). The only increase in attendance occurred between incubation and pipped eggs, followed by a progressive decrease in attendance.

**Attendance in the Nesting Area by Males.** There was a significant difference in the proportion of time males spent in the nesting areas over the different periods (Kruskal-Wallis $H = 29.1$, df = 11, $P < 0.002$, $N = 55$; Fig 1). As with females, attendance was negatively correlated with developmental periods (Kendall Rank Correlation Coefficient Tau = $-0.498$, $Z = -5.365$, $P < 0.001$, $N = 55$). In contrast to females, males spent little time in the nesting area between incubation and pipped eggs, but equal or more time than the females thereafter.

Female attendance overall in 55 nesting areas was higher than that of the males (Mann-Whitney $U = 1145.5$, $Z = -2.198$, $P < 0.028$). Despite some differences, female and male attendance overall was positively correlated (Kendall Rank Correlation Coefficient Tau = 0.37, $Z = 3.986$, $P < 0.001$, $N = 55$).

**Simultaneous Attendance in the Nesting Area by Males and Females.** There was a significant difference in the proportion of time males and females spent at the nesting area together (Kruskal-Wallis test $H = 35.75$, df = 11, $P < 0.001$, $N = 55$; Fig. 1). Moreover, attendance was negatively correlated with developmental periods (Kendall Rank Correlation Coefficient Tau = $-0.611$, $Z = -6.585$, $P < 0.001$, $N = 55$).

Simultaneous attendance by males and females decreased sharply before hatching, remained rather stable until the young were 40 d old, and then decreased gradually.

**Attendance at the Nest Site by Females and Males.** There was a significant difference between developmental periods in the proportion of time that females spent at the nest sites (Kruskal-Wallis $H = 43.9$, df = 11, $P < 0.001$, $N = 55$; Fig. 2). Males exhibited a similar trend (Kruskal-

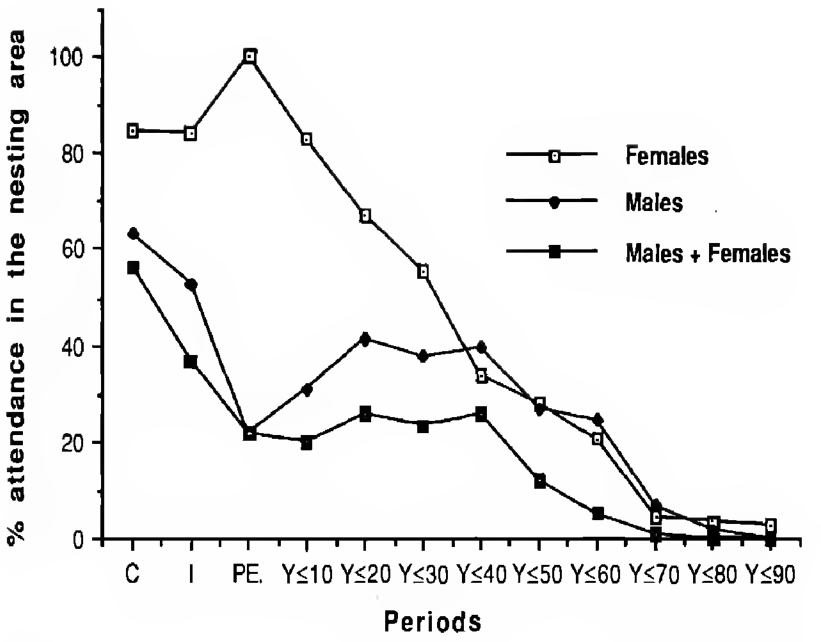


Figure 1. Proportion of observation time during which the nesting areas were attended by females, males, and males and females simultaneously. C represents courtship, I incubation, PE eggs pipping and Y < $N$ the age of the young in days.

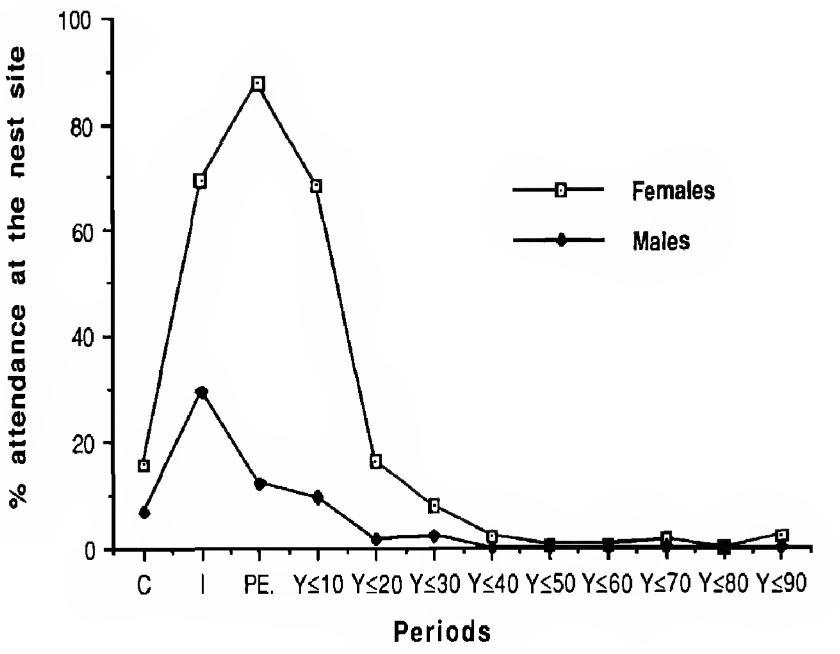


Figure 2. Proportion of observation time during which the nest sites were attended by females and males.

Wallis $H = 35.3$, df = 11, $P < 0.002$, $N = 55$; Fig. 2). As might be expected, attendance at the nest decreased as young grew and more presumably able to thermoregulate on their own (females, Kendall Rank Correlation Coefficient Tau = $-0.614$, $Z = -6.622$, $P < 0.001$, $N = 55$; males, Kendall Rank Correlation Coefficient Tau = $-0.621$, $Z = -6.696$, $P < 0.001$, $N = 55$). Attendance at the nest site sharply increased between courtship and incubation (for females Mann-Whitney $U = 1$, $P < 0.016$, $N_1 = 4$, $N_2 = 5$; for males Mann-Whitney $U = 2$, $P < 0.032$, $N_1 = 4$, $N_2 = 5$). However, when comparing the males to the females, it is worth noting the decrease in attendance time by the males between incubation and pipped eggs, while there was an increase in attendance time by the females over this period.

Overall female attendance at the eyrie was higher than that of the males (Mann-Whitney $U = 1063.5$, $Z = -2.788$, $P < 0.005$, $N_1 = N_2 = 55$). However, female and male attendances were positively correlated (Kendall Rank Correlation Coefficient Tau = 0.577, $Z = 6.22$, $P < 0.001$, $N = 55$).

## DISCUSSION

The results suggest that both sexes spent much of their time at the nesting area during courtship. The maximum attendance of the males at the nesting areas occurred at this time. In contrast, attendance at actual nest sites varied among individuals and was significantly lower during courtship for both sexes than the attendance at the nest site during incubation. No quantitative results were available in the literature regarding the courtship period.

Both males and females incubated during the day, with an average female/male attendance ratio of 70 to 30, respectively. Males of different pairs ranged from about 15 to 50% in the proportion of time spent incubating. Females alone seemed to incubate during the night. These results are similar to those of other studies where males spent 12–33% of the daytime in incubation (Cade 1960, Herbert and Herbert 1965, Formon 1969, Nelson 1970, Enderson et al. 1972, Cramp and Simmons 1980, Ratcliffe 1980, Hustler 1983, Monneret 1987). Nelson (1970) stated that both sexes shared the incubation of the eggs in Langara Island, with only the female incubating during the night. According to Nelson, the proportion of the incubation done by each sex during daylight hours depended on the pair concerned and on the stage of incubation. He estimated that at mid-incubation, the male's share was probably between 30 and 50% of daytime incubation.

Concerning the attendance time during the pipped eggs period, there was an average female/male ratio of about 90 to 10 in this study. No comparable quantitative data are available in the literature. This phase is often quoted as the "end of incubation." Nelson (1970) pointed out that toward the end of incubation, the female tended to perform a higher proportion of the incubating. Monneret (1987) observed that males almost never came to the nest site after hatching. In the present study, there was an increase in the attendance in this period by the females at the nest site and a decrease by the males. The analysis of male-female relationships within pairs (Carlier and Gallo submitted for publication) underlies a possible explanation. It is suggested that from the moment of hatching the adults are motivated (need) both to feed and to brood the young. Therefore, it is the female, dominant over her mate, who does not "accept" the male at the nest site any longer and performs all brooding. The male hunts and brings prey to the nesting area, where the female most often takes the prey from him before he can attempt to perform feeding. In the same way, Nelson (1970) wrote, "Because, during the incubation and nestling phases, the female appears to be the dominant member of the pair at the nest ledge, the male's parental shifts are determined by the female's allowing of his take-over of incubation duties."

Further, Treleaven (1977) suggested that the male was not 'tolerated' at the eyrie by the female from hatching until the young were 10 d old. From a cognitive approach, immediately after egg pipping the brooding status changes from the point of view of the parents (Carlier and Gallo 1989). It results in a stronger investment from each of the parents, leading then to a "competition" for the care for the young.

After the "pipped egg phase," female attendance at the nest site decreased. This decrease become especially steep when young were >10 d old. These results are consistent with those of Nelson (1970) and those of Enderson et al. (1972). Such a significant decrease in attendance among the males was not observed between eggs pipping and young under 10 d (about 10% for both periods). These results may be explained by the female's dominance over the male. The 10% attendance by males may reflect what the females "allowed" them to do. Therefore, the males might have spent more time at the nest site if they were permitted to do so. The comparison between the males' attendance at the nesting area and the simultaneous male and female attendance in the nesting area suggests that the males may take advantage of the absence of the females in order to stay in the nesting area. The males' trend does not decrease during the nestling stage. Brown (1976) noted that males occasionally brooded older young during adverse weather. Moreover, it is worth noting that when the young were more than 20 d old, the attendance by the adults at the nest site was limited to prey transfer and feeding.

Cade (1960) estimated the fledgling dependence to be 70 d in length. This is consistent with our study where the attendance of at least one adult in the nesting area revealed a sharp decrease when young were 60–70 d old.

As a way of explanation of the sharing duties, Nelson (1970) pointed out that the female, by virtue of her larger size, is more efficient at incubating than is the male, and that the male peregrine is too small to brood or cover the nestlings properly or comfortably. However, it is worth noting that in no case could a motivation be directly inferred from an assumption about an ultimate function. Therefore, even if we cannot definitely assert that males and females have about the same parental motivation, whatever the breeding stage, male-female interactions should be taken into account when attempting to explain the attendance differences between sexes.

Although attendance by males and females varied between pairs, there was always at least one adult in the nesting area from incubation to egg pipping. Therefore, no matter how different the sharing duties within pairs may be, they did not result in any lack of protection for the brood.

RESUMEN.—La atención al sitio del nido de cinco pares de halcones silvestres de la especie *Falco peregrinus brookei,* fue estudiada durante el período de reproducción, en Query, al sudoeste de Massif Central, Francia. Las observaciones fueron realizadas durante las mañanas o las tardes de 113 días, para un total de 525 horas de observaciones. 12 períodos de desarrollo fueron distinguidos según la presencia, la ausencia, o la conducta de las crías. En general, la atención de las hembras en el área del nido y en el sitio mismo del nido fue significativamente mayor que la de los machos; la atención dada por ambos miembros de la pareja, sin embargo, fue positivamente correlacionada. Entre períodos de desarrollo hubieron significativas diferencias en la proporción de tiempo en que los nidos fueron atendidos; y en el total, con el transcurrir del tiempo, hubo una tendencia decreciente en la atención. Sin embargo, la atención al nido por parte de las hembras aumentó entre la incubación y el nacer de los pollos, mientras que decreció la que fue dada por el macho. Se sugiere que las hembras, por su dominación a los machos, limitaron en éstos la atención al sitio del nido. Por tanto, el nivel de la tendencia paternal de los halcones machos no puede asumirse solamente en base a la conducta paternal observada, sin tener en cuenta, en su totalidad, las relaciones macho-hembra en el sitio del nido.

[Traducción de Eudoxio Paredes-Ruiz]

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# ARE BALD EAGLES IMPORTANT PREDATORS OF EMPEROR GEESE?

ROBERT E. GILL, JR. AND KAREN L. KINCHELOE[1]
*U.S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center, 1011 E. Tudor Road, Anchorage, AK 99503 U.S.A.*

Bald Eagles (*Haliaeetus leucocephalus*) and geese often occur together, especially at sites used by geese for migrational staging and wintering. Although numerous studies have been directed at these taxa, there are only anecdotal accounts (Parris et al. 1980, Bennett and Klaas 1986, Bartley 1988) of Bald Eagles killing healthy geese at any time of the year (but see Raveling and Zezulak 1991). Most species of geese may be too large, as suggested by Sherrod et al. (1976) and Palmer (1988), or they may not regularly allow eagles an advantageous attack position (J.M. Gerrard *in litt.*).

Here we report observations of attacks on Emperor Geese (*Chen canagica*) by Bald Eagles on the Alaska Peninsula in autumn. We discuss these and other observations of eagle-goose interactions *vis-a-vis* the role of Bald Eagles as predators of Emperor Geese.

## STUDY AREA AND METHODS

We recorded observations on the occurrence and behavior of Bald Eagles and Emperor Geese during a three-year study (1986–88) of Cackling Canada Geese (*Branta canadensis minima*) staging at Cinder and Hook lagoons (57°15'N 158°15'W), two large, adjacent estuaries on the northeastern Alaska Peninsula (Gill et al. in press). Observations were made daily from blinds and on foot between the last week of September and the last week of October each year. We also interviewed several long-time residents of the Alaska Peninsula and most biologists involved in on-ground studies there during the past 25 yr.

Several hundred Bald Eagles are year-round residents of the Alaska Peninsula, but probably fewer than 40 pairs nest along the north side of the peninsula (Wright in press, Dewhurst in press). Each year, however, between July and November, many eagles gather among five or six prominent estuaries along the north side of the peninsula. They are presumably attracted to these sites because of the large runs of anadromous fish and the large concentrations of staging waterfowl, primarily eiders (*Somateria mollissima* and *Polysticta stelleri*) and geese (Cackling Canada, Emperor, and Brant geese *Branta bernicla*). Indeed, between September and November each year most of the entire population of Emperor Geese (about 90 000 birds) stages on these estuaries (Petersen and Gill 1982, King and Brackney 1991). About 15 000 of these use Cinder-Hook Lagoon (R. Gill unpubl.).

## OBSERVATIONS

Our first observation of an attack occurred on 12 October 1987, when we saw an adult Bald Eagle in aerial pursuit of a flock of 12 Emperor Geese. The eagle separated a juvenile goose from the flock, grabbed it by the back and neck with its talons, and then flew with it for about 400 m before landing and eating the goose.

Our second observation, on 27 October 1987, involved an attack on a goose by six eagles. One adult eagle flushed a flock of 40 Emperor Geese and attacked an adult, knocking it from the air. The eagle landed about 200 m away but did not try again to kill the goose. Over the next 20 min, five different eagles (two adult, one subadult, and two hatching-year birds) stooped individually on the goose a total of 16 times. The goose was able to evade each attack, and none of the eagles hit the goose again. About 30 minutes after the initial attack, the goose took flight from the mudflats surrounded by seven perched eagles, none of which made any attempt to attack the goose once it was in the air.

## DISCUSSION

From interviews we learned of only seven other successful attacks observed when the two species occur together on the Alaska Peninsula (September–April); five of these entailed juvenile geese (G.V. Byrd, P.J. Kust, P.E. Gundersen, and J.A. Schmutz pers. comm., R. Gill pers. observation). The sole published account, from the Aleutian Islands (Sherrod et al. 1976), documented a Bald Eagle catching an adult Emperor Goose and carrying it to a sea stack.

Another point of evidence is that Bald Eagles have frequently been seen feeding on carcasses of recently killed

[1] Present address: 5421 E. 131st Ave., Anchorage, AK 99516 U.S.A.

or injured Emperor Geese (R.D. Jones, Jr. and J.A. Pratt *in litt.*, P.J. Kust, C.P. Dau, and P.E. Gundersen pers. comm., G.V. Byrd, J.A. Schmutz, J.D. Mason and R. Gill pers. observations). Although some of these birds were known to have just been shot by hunters, the others may have been injured or killed by the eagles before the observers encountered them. Residents of Nelson Lagoon, a village along the northcentral Alaska Peninsula, also have reported that in years in which the onset of winter was sudden and severe (e.g., 1970 and 1971), Bald Eagles concentrated there and frequently killed and fed on Emperor Geese. Residents have observed eagles attacking geese physically trapped in ice, geese whose flight was encumbered by freezing spray, and geese weakened to the extent that they were unable to fly. Such situations at Nelson Lagoon often entailed a few hundred geese (P.E. Gundersen *in litt.*, P.J. Kust and S. Johnson pers. comm.).

Among all species of waterfowl present during our study, Emperor Geese exhibited the most consistent and strongest flight response to the presence of Bald Eagles. They often took flight when an eagle was several kilometers away and well before most other species (e.g., Cackling Canada Geese) reacted to the eagles' presence. Since Bald Eagles do not occur on the breeding grounds of the Emperor Goose, the flight response by geese must have been reinforced through frequent and successful attacks on the goose's staging and wintering grounds.

Furthermore, observations suggest that juvenile Emperor Geese may be more susceptible to eagle predation than adults. Healthy adult Emperor Geese are relatively large ($\bar{x}$ = 2680 g ± 55 SE, range = 2230–3100 g, $N$ = 22; C.P. Dau unpubl. data) compared with most prey taken by Bald Eagles (Sherrod et al. 1976, Gerrard and Bortolotti 1988). However, juvenile Emperor Geese are smaller ($\bar{x}$ = 2230 g ± 98 SE, range = 1900–2680 g, $N$ = 8; C.P. Dau unpubl. data). Because juvenile geese are also less experienced and have overall greater nutritional demands than adults (Wypkema and Ankney 1979, Giroux and Bédard 1988, Raveling and Zezulak 1991), the harsh conditions throughout the winter range may weaken them and render them more vulnerable than adults to predation.

Another measure of the effect eagles have on geese is the number of disruptions to feeding flocks of geese caused by eagles. One or more Bald Eagles were present on the area on 70 of 81 d, representing 192 eagle-days of sightings. Mass disruptions of feeding geese by Bald Eagles occurred 71 times during the study, or on average about once a day. Disruptions were most prevalent ($\bar{x}$ = 2.7/day) towards the end of the staging period in mid- to late-October each year, when numbers of geese and eagles reached their peak. On a few days during this period as many as 8–10 disruptions were noted. Numerous other disruptions of geese were observed, many were too distant to identify the cause, but behavior of the flocks suggested that eagles were involved.

The evidence we have presented suggests that Bald Eagles frequently attack live Emperor Geese, particularly juveniles. That this species is rarely recorded as eagle prey (Murie 1940, Krog 1953, White et al. 1971, 1977, Sherrod et al. 1976) is probably an artifact of the relatively short periods when eagles, geese, and biologists occur together. For example, by early May, when most eagles in southwestern Alaska hatch and begin feeding their young, Emperor Geese have already migrated to the breeding grounds (Sherrod et al. 1976, Petersen and Gill 1982, Gill et al. 1981, Byrd and Williams in press).

Given the recent decline in the Emperor Goose population (Petersen and Gill 1982, U.S. Department of Interior 1989, King and Brackney 1991) and the relatively large and stable population of Bald Eagles in southwestern Alaska, any assessment of winter mortality in Emperor Geese needs to consider predation by Eagles. This information is especially needed for areas such as the eastern Aleutian Islands, where geese remain for long periods, eagles are abundant, and frequent and harsh winter storms may directly kill geese or lead to increased predation by eagles.

RESUMEN.—La presencia tanto de águilas *Haliaeetus leucocephalus* como de gansos *Chen canagica* ocurre al mismo tiempo en el sudoeste de Alaska y las Islas Aleutinas, entre septiembre y abril. Durante los estudios en la penísula de Alaska entre 1986 y 1988, hemos observado dos ataques de Águila Cabeciblanca contra los gansos. Presentamos tanto estas observaciones como otras que documentan la depredación causada por esta especie de águila en el ganso *C. canagica*; también se discute el rol de esta ave raptora como depredadora de ellos, especialmente cuando las víctimas están en su etapa juvenil. La reciente declinación poblacional de gansos, y la grande y estable población de *H. leucocephalus,* justifican adicionales estudios sobre esta águila como factor en la mortalidad que en invierno ocurre en los gansos.

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# Birds Present in Pellets of *Tyto alba* (Strigiformes, Tytonidae) from Casa de Piedra, Argentina

Jorge I. Noriega
*Facultad de Ciencias Naturales y Museo de la Plata, 1900 La Plata, Argentina*

Rosana M. Aramburú
*Becaria Comisíon de Investigaciones Científicas, Ministerio de Asuntos Agrarios, 1900 La Plata, Argentina*

Enrique R. Justo
*Facultad de Ciencias Exactas y Naturales, 6300 La Pampa, Argentina*

Luciano J.M. De Santis
*Facultad de Ciencias Naturales y Museo de la Plata, 1900 La Plata, Argentina*

The Barn Owl (*Tyto alba*) is the strigiform with the most world-wide distribution. The diet of this raptor is predominantly composed of small mammals (Jaksić et al. 1977, Massoia 1983, Torres Mura and Contreras 1989). Insects make up a small contribution to the Barn Owl's diet as do other non-mammalian vertebrates. The species of birds that have been preyed upon have been poorly documented in the Argentine ornithological literature (Justo and De Santis 1982, Soncini et al. 1985, De Santis and Pagnoni 1989, Nores and Gutierrez 1990, Noriega et al. 1990). Likewise, reports from other regions are also scanty (Herrera and Jaksić 1980, Cerpa and Yanez 1981), and usually list birds as unidentified. Identification problems of avian prey arise as consequence of the great osteologic homogeneity of birds, and the lack of keys or descriptions that could allow a more specific determination. Another difficulty is the extreme fragility of the avian bones found in the pellets.

The aim of this work is to inform about a case of high ornithophagy from Casa de Piedra in La Pampa, Argentina (38°12'S 62°12'W), and to give a list of avian prey remains in 156 pellets. The study area was in the Patagonian zoogeographic domain (Ringuelet 1961). The pellets were collected during November 1983 on the terraces bordering the Colorado River. The identification was made by comparing the remains of humeri and skulls in pellets with known specimens deposited in the Vertebrate Paleontology Division of La Plata Museum.

## Results and Discussion

From a total of 259 prey items (Table 1), the number recognizable as birds was 103 (39.8%). The remaining items were mammals, which were described elsewhere (Montalvo et al. 1984). Two species of birds, *Zonotrichia capensis* and *Mimus patagonicus*, comprised 62% of all bird prey eaten by the owls.

Table 1. Prey in the diet of *Tyto alba* from Casa de Piedra, La Pampa (Argentina).

| Prey | Number | Percentage |
|---|---|---|
| **Mammals** | 156 | 60.2 |
| **Birds** | 103 | 39.8 |
| **Charadriidae** | | |
| Unidentified Charadriidae | 1 | 0.4 |
| **Emberizidae** | | |
| *Zonotrichia capensis* | 38 | 14.7 |
| *Diuca diuca* | 6 | 2.3 |
| *Phrygilus fruticeti* | 3 | 1.2 |
| Unidentified Emberizidae | 6 | 2.3 |
| **Mimidae** | | |
| *Mimus patagonicus* | 26 | 10.0 |
| **Furnariidae** | | |
| *Cinclodes fuscus* | 6 | 2.3 |
| *Synallaxis albescens* | 5 | 1.9 |
| *Leptasthenura* sp. | 1 | 0.4 |
| *Pseudoseisura lophotes* | 1 | 0.4 |
| *Upucerthia dumetaria* | 1 | 0.4 |
| Unidentified Furnariidae | 1 | 0.4 |
| **Hirundinidae** | | |
| *Progne modesta* | 2 | 0.8 |
| **Columbidae** | | |
| *Zenaida auriculata* | 1 | 0.4 |
| **Rhinocryptidae** | | |
| Unidentified Rhinocryptidae | 1 | 0.4 |
| **Unidentified Passeriformes** | 4 | 1.5 |

The diet included some species with a wide distribution, such as *Zonotrichia capensis, Progne modesta,* and *Zenaida auriculata.* Typical Chacoan species belonging to central domain (Ringuelet 1961), *Pseudoseisura lophotes* and *Synallaxis albescens,* were also found. A marked Patagonian influence was noted through the inclusion of *Mimus patagonicus, Diuca diuca, Phrygilus fruticeti, Cinclodes fuscus* and *Upucerthia dumetaria.* The presence of these species might reflect the zoogeographic placement of Casa de Piedra in the ecotone between the Patagonian and central domains.

This unusually high predation on birds is difficult to explain. Hardy (1989) explained a case of ornithophagy by a seasonal decline in marsupial and rodent populations, a facultative response to the abundance of a secondary food resource. Alternatively, this unusual result may reflect individual differences on the part of an undetermined number of individual Barn Owls studied.

RESUMEN.—La presencia de aves en la dieta de *Tyto alba* está poco documentada en la Argentina. En egagrópilas provenientes de la provincia de La Pampa (Argentina) hemos registrado una elevada ornitofagia, constituyendo las aves el 40% de las presas. Estas aves estaban representadas por 11 especies con predominio de Passeriformes.

Estudios de mayor profundidad son necesarios, resultando difícil por el momento explicar esta desviación hacia el consumo de aves.

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# Great Horned Owls Do Not Egest Pellets Prematurely When Presented With a New Meal

Gary E. Duke
*Department of Veterinary PathoBiology, University of Minnesota, 1988 Fitch Ave., St. Paul, MN 55108 U.S.A.*

Sue Jackson
*Department of Physiology, UCLA School of Medicine, Center for the Health Sciences, 10833 Le Conte Ave., Los Angeles, CA 90024-1751 U.S.A.*

Oral A. Evanson
*Department of Veterinary PathoBiology, University of Minnesota, 1988 Fitch Ave., St. Paul, MN 55108 U.S.A.*

In a review of research relating to the physiological mechanism and regulation of pellet egestion in raptors (Duke 1989) it was clear that several aspects of regulation require further study. In particular, the role, if any, of cephalic, or even voluntary control, is very poorly understood. It has been shown recently that in laboratory studies, the meal to pellet interval (MPI, Balgooyen 1971) of captive Great Horned Owls (*Bubo virginianus*) may be influenced by the visual presence of other Great Horned Owls (Duke et al. 1991). Also, in fasted Great Horned Owls with basal gastric contractile and secretory activity, both gastric motility (Duke et al. 1976b) and gastric secretion (Mosher and Duke 1985) were enhanced by the sight of food (dead mice). These findings suggest a cephalic control of gastric function. Since pellets are formed and egested from the muscular stomach (Rhoades and Duke 1977, Duke et al. 1976c) it is possible that cephalic mechanisms could be involved in egestion as well. Hawks fed before mid-afternoon egest at dawn the following day (Balgooyen 1971, Duke 1989). Clearly time, or dawn, is not "sensed" by the stomach, so cephalic input must be involved.

The purpose of the present study was to determine if Great Horned Owls are able to egest pellets slightly before the expected egestion time if presented with a new meal of mice. If digestive efficiency of the new meal is reduced by the presence of undigestible remains of a previous meal in the stomach, owls might stand much to gain if they could prematurely terminate a digestion process (i.e., egest) that was nearly complete to avoid this compromise in digestive efficiency.

## Methods

Four healthy, but permanently crippled Great Horned Owls, obtained from the rehabilitation clinic at The Raptor Center, University of Minnesota, were used. Two were presumably males, and two were presumably females based on their body weights (Table 1). They were trained to eat 40–60 g/kg of thawed mice between 0800 and 0815 H daily. This feeding time was selected for the convenience of the authors. While MPIs for meals fed in the evening are slightly longer than for those fed in the morning, the egestion mechanism and process appears to be constant regardless of feeding time (Duke and Rhoades 1977). The owls were weighed weekly to monitor their health; all maintained, or slightly gained, body weight.

The owls were kept individually in two identical animal holding rooms between 4 December 1991 and 30 April 1992. Lights were automatically turned on in these rooms from 0600–1800 H daily and temperature and relative humidity were maintained at 20–22°C and 45–50%, respectively. Access to the rooms was limited to the authors who regularly fed the birds and maintained the rooms. Chambers in which owls were kept and automatic egestion timing devices have been previously described (Duke et al. 1976a, Duke and Rhoades 1977).

The two smaller owls were tested first. They were fed daily for 3 wk, then a mean (±SD) MPI was determined. This feeding schedule was maintained for the next 4 wk; however, they were fed 1 d per week (selected randomly) at a time equivalent to one SD of the mean prior to the expected pellet egestion time. The two heavier birds were tested similarly.

Assuming that a high meal mass to pellet mass ratio reflects greater digestive efficiency than a low ratio (Duke 1989), we measured pellet masses and meal to pellet intervals (MPIs) in Great Horned Owls given the opportunity to egest the pellet from a previous meal when presented with a new meal. We compared these data with corresponding values for the same individuals fed at 0800 H daily permitting egestion of the "old" pellet some 9–11 hr before ingestion of a new meal.

## Results and Discussion

A pellet was egested only twice in 26 trials involving a new meal being presented prior to egestion from a previous meal. This occurred first with one of the presumed males; the egestion occurred within 2 min of entry of the attendant (G.E.D.) into the room. Because the pellet compaction

Table 1. Mean meal to pellet intervals (MPI) and body masses for four Great Horned Owls. MPI from "experiments" were those in which two feedings resulted in only one pellet.

| Bird Number | Body Mass (g) Start | Body Mass (g) End | MPI[1] Control (1 Meal) | N | MPI[1] Experiment (2 Meals) | N |
|---|---|---|---|---|---|---|
| 1 | 1102 | 1180 | 15.12 (0.66) | 56 | 25.60 (1.71) | 8 |
| 2 | 989 | 1195 | 14.98 (0.72) | 58 | 28.05 (1.90) | 8 |
| 3 | 1670 | 1710 | 13.17 (0.20) | 30 | 23.82 (0.47) | 5 |
| 4 | 1760 | 1820 | 12.48 (1.05) | 26 | 23.37 (2.82) | 5 |

[1] MPI given in decimalized hours (not h:min).

Table 2. Mean daily pellet masses (g) and dry meal mass : pellet mass ratios of Great Horned Owls.

| | Dry Pellet Mass (g) | | Meal Mass/Pellet Mass (dry) | |
|---|---|---|---|---|
| | Control[a] (1 Meal Pellet) | Experimental[b] (2 Meal Pellet) | Control (1 Meal Pellet) | Experimental (2 Meal Pellet) |
| Males | 1.88 | 3.36 | | |
| Females | 3.61 | 6.37 | | |
| Both Sexes | | | 8.49 (0.42) | 10.00 (0.73) |

[a] Pellets collected during control periods are all from one meal.
[b] Pellets collected from experiments in which a meal was fed just prior to the expected pellet egestion represent two meals.

and egestion process averages 12-21 min in duration in Great Horned Owls (Kostuch and Duke 1975, Rhoades and Duke 1977), this pellet was probably not egested in response to entry of the attendant. In the second instance, one of the presumed females refused to eat when food was presented at one SD before expected egestion time. The food was left with her. At approximately 30 min after presentation of the food, she egested a pellet, then immediately ate the new meal. This failure to eat within 15 min perhaps indicated that an egestion process may have been initiated by presentation of a new meal. We were prepared to leave mice with an owl for up to 30 min before removing them to see if egestion followed by eating would occur. On three other occasions, owls had egested prior to our entry to present them with a new meal.

Meal to pellet intervals determined in this study (Table 1) were similar to those determined in previous studies involving Great Horned Owls (Duke 1989, Duke et al. 1991). Dry pellets representing mainly hair and bones from two meals were nearly twice the weight of pellets from one meal (Table 2). The ratio of meal to pellet mass was slightly greater for pellets representing two meals as compared to those from one meal (Table 2). Previous studies have shown that digestion is more thorough (i.e., pellets are relatively lighter), if egestion is delayed (Duke 1989). Also, in Barred Owls (*Strix varia*) whose body weights were experimentally lowered by fasting, MPIs were longer, pellets were lighter in mass and digestion was more thorough (Duke et al. 1980). Presumably in the case of two-meal pellets, digestion of the first meal was considerably more thorough because digestion time for that meal was considerably longer. The MPI for two-meal pellets was slightly less than twice as long as for one-meal pellets (Table 1), so digestion time for the second meal was only slightly less than for a single meal. Thus, eating a second meal before egesting a pellet from an earlier meal is not only not detrimental, but is apparently slightly beneficial in terms of overall digestive efficiency.

We had hypothesized that when presented with a new meal just prior to expected egestion of a pellet from the previous meal, owls would either a) not eat immediately but initiate egestion and eat within about 15–30 min, b) eat the new meal despite the undigested remains of the previous meal still in the muscular stomach, or c) not eat within 30 min, miss the opportunity to ingest the new meal and egest at the expected time. We expected a) but observed b). So, owls don't have to egest the remains of one meal before eating a second meal, and they don't have to miss the opportunity to ingest a new meal if one becomes available. Further, overall digestibility and gain of nutrients is apparently not diminished but is enhanced, by eating the second meal. Of course, a wild owl could also catch the prey, hold it or cache it, then eat it after pellet egestion occurs at the "expected" time. This did not occur during the premature feedings. The latter situation has been observed in Saw-whet Owls (*Aegolius acadicus*) after catching a prey item which was larger than could be ingested in a single meal (Mumford and Zusi 1958, Collins 1963) and in Barred Owls (*Strix varia*) which "incubated" the unconsumed portion of a Ruffed Grouse (*Bonasa umbellus*) to prevent it from freezing (Fuller 1978 pers. observation).

Presumably consumption before egesting the remains of a previous meal is limited by gastric capacity and could only occur once or twice before the stomach is too full of undigestible remains to allow a new ingestion. This remains to be investigated. Whether small owls (e.g., Screech owls *Otus asio*) which eat relatively more per gram body weight per day (Duke et al. 1976a) than large ones would also eat a second meal before egesting the remains of a previous meal should also be investigated.

RESUMEN.—Hipoteticamente se ha sostenido que: 1. La eficiencia digestiva de una nueva comida podría ser disminuída si la que fue previamente ingerida está aún, par-

cialmente digerida, en el conducto digestivo. 2. El Búho Cornado Americano (*Bubo virginianus*) podría prematuramente regurgitar una egagrópila si se le es dada la oportunidad de ingerir una nueva comida.

Se determinó la desviación estandard de la media de los intervalos de regurgitación en cuatro búhos. Luego, en un día (seleccionado al azar) de cada una de las cuatro semanas de estudio, y a una desviación estandard antes del lapso en que se produciría la regurgitación, una nueva comida se les fue presentada. Sólo una regurgitación fue, al parecer, motivada por esta comida anticipada. En todas las demás comidas anticipadas, los residuos no digeribles de dos comidas fueron regurgitados en una egagrópila. El peso de las egagrópilas de dos comidas fue ligeramente menor que el doble del peso de la egagrópila de una comida; y la proporción comida/peso de egagrópila fue ligeramente mayor para egagrópilas provenientes de dos comidas. Así, pues, el ingerir una segunda comida antes de regurgitar la anterior, es no solamente no negativa, sino que, aparentemente, hasta es ligeramente beneficioso para la eficiencia digestiva.

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# A Comparison of Home Range Estimates for a Bald Eagle Wintering in New Mexico

Dale W. Stahlecker
*Eagle Ecological Services, Route 7, Box 126-Z, Santa Fe, NM 87505 U.S.A.*

Timothy G. Smith[1]
*Ghost Ranch Conference Center, Abiquiu, NM 87530 U.S.A.*

Although Bald Eagles (*Haliaeetus leucocephalus*) have been extensively studied throughout their winter range during the past three decades, little information on wintering home range size has been published. Mean winter (January to March) home range of 12 radio-tagged adult bald eagles in southcentral Colorado was 311 km² (Harmata 1984). Grubb et al. (1989) reported a mean seasonal (February to March) home range of 401 km² for four immature Bald Eagles in northcentral Arizona based on inter-roost movements. Home range of four immatures in Missouri in 1976 averaged 48 km² and those of six adults and four immatures in 1978 averaged 18 km² (Griffin and Baskett 1985). McClelland et al. (in prep.) reported home ranges of 471 to 4000 km² for four adults and 102 to 386 km² for three immatures wintering separately in Montana, Utah, and California-Oregon. In all four studies minimum convex polygons were drawn that contained all radiotelemetry points but excluded non-use areas.

Using computer simulated data for which the actual home range was known, Boulanger and White (1990) showed that five commonly used home range estimators behaved with significantly different bias and precision. No one has documented the effect that a habitat that is not randomly or uniformly present in an animal's potential home range, such as rivers or lakes, has on these estimators. Wintering Bald Eagles generally concentrate in aquatic habitats (Steenhof 1978) and, if food is sufficient, utilize them to the exclusion of other nearby habitats (Stalmaster 1987).

## Study Area and Methods

Abiquiu Reservoir is on the Rio Chama in north-central New Mexico (Fig. 1A). The authorized storage pool is 1896 m, at which level the surface area is 1675 ha. The reservoir is surrounded by extensive pinyon (*Pinus edulis*)-juniper (*Juniperus* sp.) savannah. Dead Cottonwoods (*Populus angustifolia*) are present in two bays while live cottonwoods line the Rio Chama. Winter temperatures are generally moderate, but in mid-February 1988 open water on the reservoir was restricted to two pools of 5 and 15 ha. Open water gradually increased in area until by mid-March the entire reservoir was ice-free. The Rio Chama remained >75% ice-free during the same period.

An adult male Bald Eagle was captured at Abiquiu Reservoir, New Mexico, on 13 February 1988 in a padded leghold trap (Harmata 1985) buried in a shoreline knoll. He was measured, radiotagged and released within 4 hr, 4 km across the lake from the point of capture. Gender was later confirmed by his copulatory position with an adult female who wintered in close association. We monitored his movements and behavior, often from dawn to dusk, on 29 of the 38 d he remained in the study area. During that period he was perched 191 hr; we had visual contact during 184 hr (96%). We utilized this extensive data set to characterize his wintering habits and to compare home ranges produced by five estimators.

## Results and Discussion

The eagle was captured at the 15 ha pool; he continued to forage over the lake after release. Of 30 prey captures or foraging attempts observed, 22 (73%) were fish, 4 (13%) were waterfowl, and 4 (13%) were not identified. His primary night roost was in a flood-killed cottonwood (Fig. 1A). He roosted there 31 of the 38 (82%) nights he remained in the study area after capture. He returned to this reservoir roost even when he foraged along the Rio Chama in March. His secondary roost, on the west slope in a narrow canyon on the upper lake (Fig. 1A), was used primarily after days with strong southwest winds or after human activity (i.e., boats) near his primary roost.

A perching location was used for home range analysis if the eagle remained there for more than 30 min. Though true statistical independence (Swihart and Slade 1985) was probably not obtained, we assumed biological independence because this time period would have allowed the eagle to move throughout his home range (Lair 1987, Ganey and Balda 1989). Harmonic mean, Jennrich-Turner non-circular ellipse, weighted non-circular ellipse, and minimum convex polygon home ranges were calculated by the computer program HOME RANGE (Samuel et al. 1985), based on the assumptions and restrictions described by Samuel and Garton (1985). Home range size was also calculated for a minimum convex polygon drawn to ex-

[1] Present Address: Submerged Cultural Resources, National Park Service, 1220 St. Francis, Santa Fe, NM 87504 U S.A.

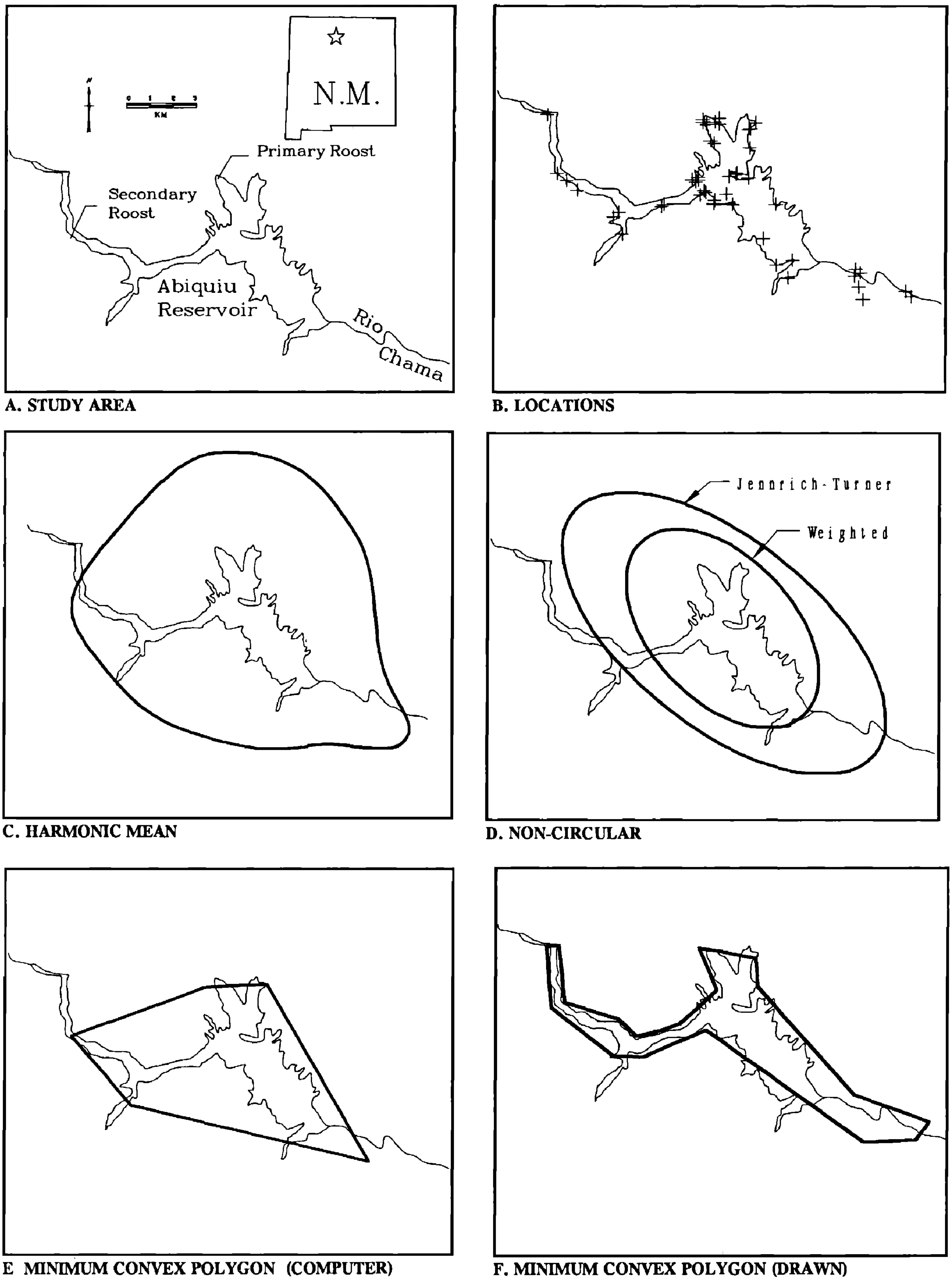


Figure 1. Study area, telemetry locations, and five estimates of home range for an adult Bald Eagle, Abiquiu Reservoir, New Mexico, February to March 1988. Computer generated estimates are at the 95% confidence level while the drawn minimum convex polygon incorporates 100% of radio-locations.

clude non-use areas (Harmata 1984, Griffin and Baskett 1985, Grubb et al. 1989).

All 271 documented perch locations were on 45 perch trees and all 45 perches (Fig. 1B) were used at least once for more than 30 min. Estimates of the eagle's home range ($km^2$) based on 126 perch uses >30 min were: harmonic mean = 170.0 (Fig. 1C), Jennrich-Turner non-circular ellipse = 105.0 (Fig. 1D), weighted non-circular ellipse = 58.3 (Fig. 1D), minimum convex polygon (computer) = 57.6 (Fig. 1E), and minimum convex polygon (drawn) = 16.1 (Fig. 1F).

All four computer generated estimates of the eagle's home range included considerable areas of upland habitat that the eagle never used (Fig. 1). All of his perches were adjacent to or overlooking Abiquiu Reservoir or the Rio Chama. Further, all direct flights we observed were over the reservoir or along the river, and most soaring flights were probably over or near the reservoir. Therefore the minimum convex polygon drawn to include only the aquatic habitat used by the eagle provided the best estimate of his winter home range (Fig. 1F).

The home range estimates generated by computer were larger because there was no means of recognizing unused upland areas as different from the aquatic areas the eagle used and deleting them. Unless a program is developed that can include habitat availability and species preferences, these programmed estimators will not be suitable for situations where habitats are not homogenous or random.

The 16 $km^2$ winter home range in New Mexico is among the smallest reported for Bald Eagles; only in Missouri, where ten eagles had a home range mean of 18 $km^2$ in 1978 (Griffin and Baskett 1985) were comparable or smaller home ranges reported. In Missouri the radio-tagged Bald Eagles were among 100 eagles that fed primarily on carcasses where 180 000 Canada Geese (*Branta canadensis*) were concentrated. Though they centered their activities at aquatic habitats, Arizona (Grubb et al. 1989) and Colorado (Harmata 1984) radio-tagged Bald Eagles foraged more widely for mammalian carrion when these feeding areas were frozen. The Abiquiu Reservoir eagle, who fed primarily on fish, was able to meet his nutritional needs in a small winter range that did not attract nor could not have supported a large number of eagles. It is noteworthy, then, as an example of a different foraging/wintering strategy than those previously published.

RESUMEN.—Un Águila Cabeciblanca macho (*Haliaeetus leucocephalus*) que invernaba cerca del Reservorio Abiquiu en Nuevo México, y que fue capturado el 13 de febrero de 1988, fue rediocontrolado por 191 horas durante 29 de los 38 días en que permaneció en al área de estudio. Esta ave usó 45 perchas diferentes (Fig. 1B). Cada una de las 126 paradas que hizo en esas perchas, duró más del mínimo de la "independencia biológica" que es 30 min. Las estimaciones de la extensión del territorio habitado (en $km^2$), generadas por computadora, fueron: media armónica = 170.0 (Fig. 1C); elipse no circular Jennrich-Turner = 105.0 (Fig. 1D); elipse no circular concentrada = 58.3 (Fig. 1D); y polígono convexo mínimo = 57.6 (Fig. 1E). Un polígono convexo mínimo trazado para excluir áreas no usables ofreció el mejor estimado de la extensión del territorio invernal de esta ave raptora (16.1 $km^2$, Fig. 1F).

Alimentándose básicamente con peces, debido a que las aguas no se congelaron, esta águila fue capaz de satisfacer sus necesidades de nutrición en un territorio de habitación pequeño. Éste fue menos extenso que los territorios que dan la mayoría de previos estudios publicados.

[Traducción de Eudoxio Paredes-Ruiz]

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# LETTERS

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## PRESUMPTIVE FORAGING ASSOCIATION BETWEEN SHARP-SHINNED HAWKS (*Accipiter striatus*) AND WHITE-FACED CAPUCHIN MONKEYS (*Cebus capucinus*)

Associations between monkeys and birds have been reported for several different species pairings in tropical regions of both the Old and New World. The avian associates reported are largely insectivorous and include species from Cuculiformes, Passeriformes, and Falconiformes (see references in Ferrari,[3] Fontaine[4] ). Within the latter order, this behavior has been observed in White Hawks (*Leucopternis albicollis*),[9] Plumbeous (*Ictinia plumbea*) and Grey-headed (*Leptodon cayanensis*) kites,[3] and frequently in Double-toothed Kites (*Harpagus bidentatus*).[1,4,5,8]

There may be indirect competition for food resources between the species involved in these associations, but generally it is assumed that the relationship is a commensal one: the monkeys are affected little by the presence of the birds, while the birds benefit through the capture of flushed prey. Little detailed study has been made of bird/monkey associations (although see Boinski and Scott,[1] Fontaine[4] ). It is likely that this behavior exists in a number of other avian species but remains unreported. Of particular note is that published accounts of foraging associations involve resident, rather than migratory, avian species. To my knowledge, this observation represents the first time that a migratory species (and a bird-eating raptor) has been reported to associate with monkeys in such a relationship.

On 20 December 1991, while studying the foraging behavior of migratory songbirds in Tivivies Forest Reserve, Puntarenas, Costa Rica (9°52′N 84°42′W), I observed a troop of 15–20 White-faced Capuchin Monkeys (*Cebus capucinus*) moving through a stand of Black Mangrove (*Avicennia bicolor*). During the half-hour period that I watched the monkeys, they moved approximately 100 m and were accompanied for the entire period by two immature female Sharp-shinned Hawks (*Accipiter striatus*). The hawks were distinguishable from Double-toothed Kites, the other species of similar size and appearance seen on the study area, by the absence of a black median stripe on the throat and the extent of streaking on the breast. Both Double-toothed Kites and Sharp-shinned Hawks were seen regularly in the study area from November through February. Over the 4 mo period of observations during this field season, however, I encountered capuchin troops on seven occasions and noted a commensal relationship with birds only in this single instance.

The monkeys moved through the canopy at between 7 and 15 m (canopy height 20 m). The hawks perched from 1 to 5 m apart on branches at about the height of the highest foraging monkeys (12 to 15 m). Both birds appeared to maintain positions roughly in the center of the monkey troop by making several flights each during the observation period. I observed no attempts on prey by the hawks during this time, and no potential avian prey were seen.

Monkey troops are followed routinely by a small number of avian species,[1,8] but these accounts of foraging associations have indicated the involvement of resident birds only. For example, the most consistently reported and best studied associations are between the largely insectivorous Double-toothed Kite, a resident species, and White-faced Capuchins[4,5] or Squirrel Monkeys (*Saimiri sciureus*).[1,2] Given that many migrant bird species spend more than one-half of any given year on their wintering areas,[7] it is somewhat surprising that migrant bird/monkey associations have not been recorded previously. Migrant insectivores, such as flycatchers which make use of aerial sallys to capture prey, would presumably benefit from this type of association.

Several explanations for the lack of such reports are possible: 1) Interactions between migrant birds and monkey troops may simply be rare. The Sharp-shinned Hawk is likely subject to selection for behavioral plasticity and associational learning, given that it is a species which forages on prey that vary in concentration and behavior over the course of the year and over its migration route. Thus, following monkeys is only one of several possible tactics that sharp-shins might use during the winter period; 2) Boinski and Scott[1] noted that the incidence of avian foragers at monkey troops varied with rainfall levels and arthropod abundance. They found that insectivorous birds associated more commonly with monkey troops during the wet season, when total arthropod abundance was low, than during drier periods which have greater arthropod availability. Because Sharp-shinned Hawks and other migrant birds are present during the dry season, their absence from lists of species associated with monkey troops may be solely a function of prey availability, and the relative profitability of other foraging strategies when compared with that of following monkey troops.

Previous reports of bird/monkey associations refer to species of birds which are largely, if not solely, insectivorous.[1,3,5,9] Sharp-shinned Hawks are predominantly bird-eating raptors, although they are reported to eat insects occasionally during the breeding season and on migration[6]; their diet is not described for the wintering grounds. Bird-eating raptors may be attracted to forage in association with monkeys due to the general flushing of potential prey (both insects and birds) by the troop, or because the monkey troops themselves attract insectivorous birds which are potential prey for raptors.

I thank Kim Derrickson, Jon Greenlaw and David Spector for their comments on an earlier draft. Field work was supported by funds from the Smithsonian Migratory Bird Center and the North American Bluebird Society. This work was conducted while I held a Natural Sciences and Engineering Research Council of Canada Postdoctoral Fellowship.—**Ian G. Warkentin, Department of Zoological Research, National Zoological Park, Smithsonian Institution, Washington, DC, 20008-2598 U.S.A.**

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## ROOSTING AMERICAN KESTRELS (*Falco sparverius*) DURING MIGRATION IN SASKATCHEWAN

American Kestrels (*Falco sparverius*) are summer residents over much of Saskatchewan. The density of breeding birds can be very high in the northern boreal forest,[1,2] while they are distributed more sparsely over the countryside and in urban areas in the southern prairie and parkland regions (pers. observation).[3] Fall migration generally spans mid-August to mid-September (pers. observation).

While much is known of the breeding behavior and winter ecology of the American Kestrel,[3] there are only a few observations of its roosting behavior.[4,5,6] The availability of roost sites may be an important factor in determining the distribution of kestrels, at least in winter.[3,5] Except for Merlins (*F. columbarius*) in winter (see [7] and references therein), our knowledge of roosting behavior in falcons is limited. Here we report on migrant American Kestrels congregating in an urban area to roost, as well as observations of intra- and inter-specific interactions near the roost site.

### OBSERVATIONS

All observations were made in the city of Saskatoon (52°07′N 106°38′W) (see [7] for a description of the area), with efforts concentrated near our residences on the east side of the South Saskatchewan river within the older neighborhoods The observations span 20 August to 13 September 1992, corresponding to the period of occupancy by the birds. During this period the overnight low temperature ranged from 1° to 10°C ($\bar{x}$ = 4.9 SD = 3.6; Saskatoon Weather Office data).

We were initially alerted to the presence of kestrels in the residential area by their characteristic "klee" vocalization. This call is typically given in agonistic encounters.[3] Virtually every evening during the observation period one to three kestrels were heard from within the house where one of us (GRB) lives.

Our casual searches in several parts of the city, and reports solicited from birdwatchers, suggest that many kestrels appeared in the city at dusk, generally between 1830 H and 1900 H. Rather than merely being more conspicuous, we believe that the birds actually arrived in the city in the evening. Only once during the 24 d were kestrels sighted prior to 1600 H. It is possible that some of these birds had nested in Saskatoon as there may be as many as 15 pairs in the city (I.G. Warkentin pers. comm.). The nearest nest to where most observations were made was 1.3 km away, and the family had dispersed from the area prior to 1 August. Given the time of year and relatively low density of urban-nesting kestrels, we believe most of the roosting birds were migrants entering the urban area from the countryside. On one occasion at 1900 H we drove to the edge of the city, and within a 1 km section of road bordering an agricultural field we observed three kestrels fly to and subsequently roost in the city.

Prior to roosting, kestrels normally perched on the tallest perches available, the tips of spruce trees (*Picea* spp.). On one occasion a television antenna was used as a perch, and it too was the tallest structure in the vicinity. The observations of 3 September 1992 are characteristic of the behavior we observed on most nights. Five kestrels (two of each sex and one unknown) were perched within a radius of 75 m centered around an intersection of two residential streets. During 30 min of observation that day we saw seven agonistic, intraspecific interactions. Males and females flew at other individuals of the same and opposite sex in an apparent attempt to displace the target bird. A Merlin with brown plumage also resided within this small area and made eight aerial attacks on the kestrels. These flights also appeared to be attempts at dislodging the perched kestrels, rather than predatory attacks. Both the attacking kestrels and Merlin would swoop at the perched bird and on occasion would then land approximately 1 m or less away in the same tree. While these attempts were usually unsuccessful, harassment by Black-billed Magpies (*Pica pica*) did force perched kestrels to relocate about one-half block away. The magpies would swoop at or drop on the kestrel from a hover.

Nine kestrels were observed to enter roosts. They did so 5–15 min after sunset, which varied between 2021 H and 2127 H over the study period. Each bird roosted about two-thirds the way up in a spruce, and nine different roost trees were used. The roost tree was never the tree that the bird had been perching in previously.

## DISCUSSION

Although kestrels are sparsely distributed across the prairies during migration (pers. observation),[3] it was our impression that there were remarkably fewer migrants near Saskatoon in 1992 than in previous years. From 1988 to 1991 it was not uncommon for us to find small groups of 2–14 birds within 20 km of the city. In 1992, however, we observed a total of only six individuals in 1425 km of travel in our search for kestrels across hundreds of kilometers of different roads around the city. Given we found as many birds roosting in one or two city blocks, the high density in the urban area seems remarkable.

We suspect that the attraction of the city may be its conifer trees. The countryside around the city has either few trees or typically only small, deciduous trees. Spruces are common ornamental trees and many residential blocks have five or more, although the American elm (*Ulmus americana*) constitutes 80% of the mature trees in the city (D. Domke pers. comm.). Balgooyen[6] postulated that roosting in conifers was thermally advantageous for kestrels. Merlins wintering in Saskatoon roost in spruces, and by doing so they may save 6% of their total daily energy expenditure.[8] Merlins also choose specific spruces from among those that are available; safety from predation and thermal properties may be important criteria for selection.[7] Kestrels have also been seen to enter buildings and cavities to roost.[5]

Similar to our findings, Miller[5] observed one female kestrel to roost 4–21 min after sunset. Merlins wintering in Saskatoon also enter spruce trees after sunset, but environmental factors as well as the time of sunset are important determinants of the timing of roost entry.[9]

Kestrels are known to be territorial in both the breeding season and in winter,[3,6,10] but intraspecific agonistic behavior during migration or around roost sites has not been reported. Social groups (mixed families) of juvenile and adult kestrels are commonly observed after the breeding season (pers. observation).[11,12] Similarly, despite a relatively uniform availability of spruces within any one neighborhood, roosting birds appeared to cluster. Our observations of aggressive vocal behavior and aerial attacks suggest that whatever attracts kestrels to one another during migration may potentially be in conflict with competition over roost sites.

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## FIRST RECORD OF DILUTE PLUMAGE IN ROADSIDE HAWK (*Buteo magnirostris*)

On 16 August 1986, I obtained a Roadside Hawk chick, about 4 wk age that exhibited unusual plumage coloration. This bird was confiscated at the city of Xalapa, Veracruz, México, and was taken from the nest by a bird trapper from an unknown locality, presumably in the state of Veracruz. Some weeks later the bird died and the skin was prepared. It was deposited in the author's particular collection.

Plumage of this bird differed from the normal juvenile color (brown in most parts of the body) by being a very light brown or beige on back upper wing feathers and tail. I found no references of this coloration for this species in the literature (i.e., F. Weick and L. Brown 1980, Birds of prey of the world, William Collins and Sons and Co., London, U.K., W.S. Clark and B.K. Wheeler 1987, A field guide to hawks of North America, Houghton Mifflin Company, Boston, MA U.S.A.).

I thank Juan E. Gómez-Martínez for suggestions on an earlier draft of the manuscript and William S. Clark for valuable and significant corrections.—**Sergio H. Aguilar-Rodríguez, Federación Mexicana de Halconería, A.C., Juan Soto 3, Xalapa, Veracruz, MEXICO 91000.**

*J. Raptor Res.* 27(1):50


# Review

**Wise as an owl: a resource and teacher's guide to birds of prey** by Lisa Langier. The Peregrine Fund, Inc., Boise, ID U.S.A. 76 pp.

This information package was compiled for teachers as a resource guide for students of all ages. The two sections of the guide deal with raptors and the effects of human actions on the environment. It includes a glossary, references, other potential resources and addresses of organizations dealing with raptors. There are descriptions for the construction of nest boxes and nest platforms, including diagrams and measurements.

Section one represents an excellent source for information on raptor morphology, feeding strategies, nests, migration and life span. It defines what a raptor is, and describes where to find raptors and how to identify them. The information on vision, hearing, smell and feeding strategies is particularly interesting, and is presented in a straightforward manner. There are a variety of activities, such as suggestions for art projects, poems and word puzzles, that allow the study of raptors to move beyond the constraints of a science classroom.

The guide deals with the conservation of raptors and environmental ethics. This material is directed toward older students. Raptor conservation through habitat protection, captive breeding and release, and other techniques are described. Four case studies investigate raptor conservation. Thirty-three questions are presented, in conjunction with the case studies. These questions deal not only with raptor conservation but with the larger issue of conservation of all species and habitats.

This guide, if supplemented with some other resources, provides an excellent information source for teachers investigating raptors with their students. However, it is not without problems. Some descriptions have the potential to cause confusion. A labelled drawing of a feather is incorrect. In the section on identifying raptors, the author describes one group as "buteos or hawks" and another group as "accipiters." The writing, in general, is clear and straightforward, except for some repetition. At some points in section one the author assumes that the user has no previous knowledge of raptors—a good assumption in an introductory guide. At other points the author assumes a more advanced state of knowledge. An example of this is a description of the Golden Eagle that states that Golden Eagles have feathers on their legs to the end of the tarsi. There is no explanation given of what the tarsi are. This inconsistent writing would necessitate that a teacher use other sources to add to the information in this guide. These few minor flaws do not detract from the overall product and a teacher would benefit from having this guide in her or his library.—**Jeffrey D. Smith**

*J. Raptor Res.* 27(1):51-52


# News

**1992 Annual Meeting.** Almost 500 people attended the 1992 Annual Meeting of the Raptor Research Foundation, Inc., in Bellevue, Washington, on 11-15 November 1992. The Local Committee, chaired by Lenny Young, organized an excellent meeting and even arranged for a little blue sky in the Seattle area in November!

Curt Smitch, Director of the Washington Department of Natural Resources, kicked off the scientific session with a keynote address that emphasized the need to use good science in wildlife management. Mark Stalmaster, Chair of the Scientific Program Committee, assembled a stimulating and varied array of papers for the general scientific session. Two symposia, one on the Spotted Owl, arranged by Mike Collopy and Bruce Marcot, and the other on Burrowing Owls, organized by Jeff Lincer, supplemented the general scientific session.

A sumptuous banquet on Saturday night featured a Pacific Rim theme including a performance by the Cape Fox Dancers and a presentation on "The Significance of Birds of Prey to Native Pacific Northwest Cultures." At the banquet the following awards were announced: the Fran and Frederick Hamerstrom Award to Dr. Riley McClelland, the Tom Cade Award to Les Boyd, the James R. Koplin Travel Award and the William C. Andersen Memorial Award to Laura Rivera-Rodriquez, the Stephen R. Tully Memorial Grant to Martha Desmond, and Leslie Brown Memorial Grants to Kevin McCann and G.E.A. Banfield. Watch for more information on these award recipients and their research in the next issue of *Wingspan.*

Newly elected Directors of the Raptor Research Foundation are Karen Steenhof, Mike Collopy, Josef Schmutz, and M. Isabel Bellocq. Steve Hoffman, David Bird, Mike Collopy, and Eduardo Iñigo-Elias ended terms as director. Several amendments to the bylaws were discussed and voted upon, but this action was nullified by a procedural problem discovered later.

The following resolutions were endorsed by the membership:

A) Whereas the birds of Europe are an international resource to be conserved for future generations; and
Whereas these birds are under increasing threat from human pressures; and
Whereas the majority of these birds are legally protected throughout Europe including Malta; and
Whereas the Island of Malta is an important stopover for these birds while on migration; and
Whereas Maltese bird shooters and trappers annually kill millions of these birds, including an estimated 50 000 raptors, mainly for recreation; and
Whereas such activities are neither consistent with a sustainable world or a civilized society.
Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership condemn the selfish actions of the Maltese bird shooters and trappers and urge the government of Malta to enforce the laws protecting these birds and to also encourage their conservation by promoting their non-destructive use, such as through ecotourism.

B) Whereas earth's wild flora and fauna, including those species threatened with extinction, provide a wide variety of benefits for humankind; and
Whereas many people believe that wild species have intrinsic value and a right to exist; and
Whereas the Endangered Species Act is the key federal law promoting the conservation of endangered species, and
Whereas authorization to expend money under the Endangered Species Act is required for the effective administration of endangered species conservation programs; and
Whereas past listing and recovery efforts have been substantially underfunded; and
Whereas weakening proposals such as those contained in H.R. 6134 (the Tauzin Bill) would seriously reduce the effectiveness of endangered species conservation efforts.
Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership urge President Clinton to pass the Endangered Species Act amendments (H.R. 4045, the Studds Bill) without any weakening amendments such as those contained in H.R. 6134.

C) Whereas secondary poisoning of birds of prey has been attributed to fenthion, an organophosphate chemical, both in the field and laboratory; and
Whereas fenthion is used to kill birds deemed to be pests, on a large-scale in Africa (e.g., weaverbirds) and on a smaller scale in North America (e.g., pigeons, house sparrows and starlings).
Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership urge the appropriate government agencies throughout the world to halt the further use of fenthion until it can be demonstrated that it can be used without hazard to birds of prey.

D) Whereas Joseph William Taylor was a member of the Hawk Mountain Sanctuary Association Board of Directors since 1948; and

Whereas Mr. Taylor was President of the Hawk Mountain Sanctuary Association for 25 years and guided, with wisdom and aplomb, the activities of Hawk Mountain Sanctuary.

Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership recognize Joseph Taylor's substantive contributions to raptor conservation and education and wish to extend their condolences to the members of the Taylor family, the Hawk Mountain Board of Directors, Sanctuary staff, and the members of the Hawk Mountain Sanctuary Association.

E) Whereas the Raptor Research Foundation finds that:

1. many species of raptors are widely dispersed during the breeding and wintering seasons,
2. there are numerous sites around the world at which one or more species of raptors are temporally concentrated during migration.
3. at these sites large numbers of migrating raptors can be observed with a reasonable degree of predictability,
4. no world atlas of these sites exists, and
5. a registry of internationally-significant sites could foster the conservation of raptors in a number of ways, including:
   a. stimulating public interest in the birds and their essential habitats, as well as the need to conserve them,
   b. fostering migration-related research and monitoring,
   c. helping to identify gaps in our basic knowledge of these birds,
   d. enhancing opportunities to raise funds for individual sites, and
   e. benefiting local economies through revenue from tourism.

Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership:

1. Endorse the twin concepts of an international raptor migration atlas project and a registry of sites of international importance to migrating raptors.
2. Encourage Hawk Mountain Sanctuary to pursue its goal of developing an international atlas of raptor migration, along with a registry of sites of international importance to raptors on migration.

F) Whereas Burrowing Owls depend on burrows produced by burrowing mammals (e.g., prairie dogs and ground squirrels) for breeding, roosting and escape, and

Whereas reproduction and survival of Burrowing Owls is affected strongly by the availability of such burrows, and

Whereas this need for burrows exists throughout the owls' annual life cycle and throughout their range, and

Whereas past poisoning campaigns have been remarkably effective in reducing prairie dog and ground squirrel distributions to a fraction of pre-settlement levels.

Therefore, be it resolved that the Raptor Research Foundation Board Members, Officers, and General Membership:

1. Urge all levels of the Canadian, Mexican and U.S. governments to phase out their subsidy and involvement in poisoning and other control programs aimed at prairie dogs and ground squirrels.
2. Remove prairie dogs and ground squirrels from their lists of "pest" species.
3. Prohibit the destruction of prairie dogs and ground squirrels on public lands, except when in accordance with an approved conservation plan.
4. Involve local natural history societies, in those special cases where control of prairie dogs and ground squirrels is warranted, to explore alternative biological methods of control.

G) Whereas the 1992 Raptor Research Foundation annual meeting was successful, stimulating, and entertaining for all who participated; and

Whereas the host committee chaired by Leonard Young did an outstanding job of organizing the 1992 meeting, finding both comfortable accommodations and providing lively entertainment, and

Whereas the program committee chairperson, Dr. Mark Stalmaster, organized over 100 excellent scientific presentations and prepared an excellent program booklet,

Therefore, be it resolved that the Raptor Research Foundation, Board Members, Officers, and General Membership thank all the members of the local, host and program committees for their long hours of hard work, making this annual meeting one of the best ever.

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# Abstracts of Presentations Made at the Annual Meeting of the *Raptor Research Foundation, Inc.,* Held at Bellevue, Washington, on 11–15 November 1992

## Spotted Owl Symposium

Organizers: Michael W. Collopy, *U.S. Bureau of Land Management, 3200 SW Jefferson Way, Corvallis, OR 97331,* and Bruce G. Marcot, *Pacific Northwest Forest & Range Experiment Station, USDA Forest Service, 333 SW First Ave., Portland, OR 97208*

### Single-species Versus Ecosystem Management: Lessons for the Future

Anthony, R.G. *Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, OR 97331-3803*

The spotted owl/old-growth issue has often been portrayed by the news media as owls versus people or jobs versus conservation of older coniferous forests. Actually, the spotted owl serves as an indicator species for late-successional forests to many environmentalists and managers. However, we know from basic ecological principles that different species occupy different ecological niches, therefore a single species cannot possibly represent all the requirements of a host of other species. Such is true for the spotted owl. The Northern Spotted Owl Recovery Team was charged with considering other species and older-forest ecosystems in developing a recovery plan for the northern spotted owl. In fulfilling this charge, we emphasized species that were listed federally as threatened or endangered, candidates for federal listing, state sensitive or species of special concern, and those associated with older forests. A list of 350+ species of plants and animals that occur within the range of the northern spotted owl was assembled. This list is comprised of 24 species of birds, 18 mammals, 26 amphibians and reptiles, 28 fish, 58 mollusks, 59 arthropods, 144 vascular plants, and 8 fungi and lichens. Five species are listed federally as threatened or endangered, and 155 species are candidates for federal listing. At the state level, over 100 species are listed as threatened or endangered, or designated as sensitive or species of special concern. More than 100 species are narrowly or broadly endemic to the Pacific Northwest and 190+ are associated with older forests. This effort also substantiated the importance of riparian ecosystems as approximately one-third (130+) of the species are associated with riparian areas. In addition, the 28 species of fish include approximately 800 stocks that are considered at risk and may become candidates for listing. Eighteen priority species were identified, of which the marbled murrelet and the numerous fish stocks were considered the highest priority. Information on the distribution, biology, and habitat relationships of the priority species and the ecology of riparian ecosystem was used to influence the location of some of the conservation areas for the owl. However, the extent to which this exercise could be carried out was influenced by economics and the preponderance of non-biologists on the recovery team. Consequently, the recovery plan for the northern spotted owl cannot be portrayed as a conservation plan for late-successional forests in the Pacific Northwest.

### Listing, Critical Habitat Designation, and Development of the Northern Spotted Owl Recovery Plan

Bart, J. and R. Holthausen. *Spotted Owl Recovery Team, U.S. Fish and Wildlife Service, 911 NW 11th Ave , Portland, OR 97232*

The northern spotted owl (*Strix occidentalis caurina*) was listed as a threatened species by the U.S. Fish and Wildlife Service in 1990. Following the listing, the Fish and Wildlife Service, acting under court order, designated critical habitat for the species. Concurrently, the Department of the Interior named a team to begin work on a Recovery Plan for northern spotted owls. This Recovery Plan was published as a draft in May 1992, and a final draft is expected in early 1993. The basic principles underlying the Plan are based on the 1990 report of the Interagency Scientific Committee. It recommends the establishment of 196 Designated Conservation Areas (DCAs) on federal lands, and contains guidelines for silviculture and salvage operations within those DCAs. It also contains a series of recommendations to provide dispersal habitat in the federal forest matrix between DCAs. It recognizes the contribution that can be made to recovery by private lands, and suggests ways for the contribution to be made more effective. Major issues that must be dealt with before publication of the final Plan include: 1) a consideration of demographic data which indicate an accelerating decline in the spotted owl population; 2) a review of models that might be used to evaluate the Recovery Plan and other options; and 3) a detailed description of the procedures that could be used to continually update the Plan based on new information. Success of the final Plan will depend on close coordination among federal and state agencies.

### Prey Ecology and Northern Spotted Owl Diet

Carey, A.B. *Pacific Northwest Research Station, USDA Forest Service, 3625 93rd Avenue, SW, Olympia, WA 98502*

Mammals constitute 90% of the spotted owl's diet; dietaries vary locally and seasonally, but are consistent annually at larger geographic scales. *Glaucomys sabrinus* (GLSA) is the single most important prey, accounting for 16–46% of the prey items consumed. GLSA is the only species to

occur with a frequency of >15% in all parts of the owl's range. In western hemlock and Douglas-fir forests, GLSA constitutes 47–58% of the biomass consumed, 3–4 times other species. In fall and winter, GLSA comprises 60–72% of biomass consumed. *Peromyscus* spp. and juvenile lagomorphs are 12–18% and 7%, respectively, of summer diets. In mixed-conifer forests in the southern part of the owl's range, *Neotoma fuscipes* may be up to 70% of the biomass consumed, and GLSA as little as 14%. Other species (% items consumed) are important locally: *Phenacomys longicaudus* (0–25%), *Neotoma cinerea* (0–15%), *Lepus americanus* (0–10%), *Clethrionomys* spp. (0–21%), *Peromyscus* spp. (5–31%), and *Thomomys mazama* (0–10%). There appears to be a definite selection of prey based on (1) nocturnality—otherwise *Tamiasciurus* and *Tamias* would be common prey; (2) mass of 100–400 g—adult lagomorphs are generally not taken and shrews, voles, and mice are low in frequency in diets relative to their abundance in the forest; (3) arboreality—GLSA is arboreal, *Neotoma* spp. are semi-arboreal, and *Phenacomys longicaudus* (27 g) is strictly arboreal and more frequently taken when available than the semi-arboreal *Peromyscus* (20 g) and the terrestrial *Clethrionomys* (23 g); arboreality probably relates to detectability of the prey; and (4) social behavior—the colonial *N. fuscipes* is locally concentrated in large numbers whereas the male-harem *N. cinerea* is locally concentrated in small numbers; *P. longicaudus* is also colonial, whereas *Peromyscus, Clethrionomys,* and GLSA are not. These characteristics seem to outweigh abundance: GLSA densities (mean number per ha ± standard error) in old growth are 0.21 ± 0.09 in the North Cascades of Washington, 0.5 ± 0.2 on the Olympic Peninsula, 2.3 ± 0.3 in the Western Cascades in Oregon, and 1 9 ± 0.1 in the Oregon Coast Ranges and Klamath Mountains, yet GLSA constitutes a greater percentage of the diet in Washington than in southwestern Oregon. But GLSA is probably the most consistently available nocturnal species weighing 100–300 g in old-growth western hemlock and Douglas-fir forests. GLSA reaches its highest densities in old growth (3.7/ha) and is more than twice as abundant in old forest than other types in Washington and southwestern Oregon. The amount of old forest encompassed by spotted owls in their home ranges reflects the biomass of the medium-sized prey (GLSA and *Neotoma* spp.) in old growth. Spotted owls can depress GLSA population densities by almost 50% in areas intensively used for foraging.

## A Private Landowner's Habitat Conservation Plan: The Simpson Timber Company HCP

DILLER, L.V. *Simpson Timber Company, Box 1169, Arcata, CA 95521*

In July 1990, the listing of the northern spotted owl (*Strix occidentalis caurina*) as threatened under the federal Endangered Species Act prohibited "taking" of the species. In response to this listing, the California Board of Forestry adopted regulations to avoid a take of the owls. Among other things, these regulations required retention of 500 acres of spotted owl habitat within a 985-acre (0.7-mile) circle centered on a known pair. High densities of owls (gross density approximately 1 pair/1000 acres) in and adjacent to merchantable timber stands in northern California of Simpson Timber Company created a situation in which continuing timber harvest and avoiding a take were not possible. This prompted Simpson to seek a permit from the U.S. Fish and Wildlife Service to allow take of spotted owls incidental to its timber harvest operations. As part of the permit application, the company drafted a Habitat Conservation Plan (HCP) for the owl. Intensive surveys and analysis of nesting sites and stands indicated that spotted owls on and adjacent to Simpson property were recolonizing and successfully reproducing in stands as early as 35–45 years following harvest. The results of these studies were used to project future owl habitat and develop the major premise of the HCP: that even when timber harvest was accounted for, potential owl habitat would more than double over a 30-year planning period. In addition, the plan included several other conservation strategies including setting aside 39 areas totalling 13 000 acres where timber harvest would not occur, establishing a 35 000 acre "Special Management Area" that would maintain at least 20 pairs of owls and where "no take" of owls would occur, continuing the spotted owl research program, and managing stands to accelerate the development of future owl habitat.

## Demographic Studies of Northern Spotted Owls

FORSMAN, E.D. *USDA Forest Service, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331*

Between 1985 and 1987, 5 different demographic studies were initiated to determine population parameters of northern spotted owls. These studies include the Willow Creek Study in northwestern California, Medford BLM Study in southwestern Oregon, Rosenburg BLM and H. J. Andrews Studies in western Oregon, and the Olympic Peninsula Study in western Washington. All 5 studies used mark-recapture techniques to assess age and sex-specific survival rates. Fecundity was assessed by counting the number of young that left the nest. Population growth rates (lambda) were calculated based on birth and death rates of females. Estimates of lambda indicated that populations in all 5 study areas were declining. Furthermore, a meta-analysis in which estimates from all 5 areas were examined together, indicated a decreasing trend in annual adult female survival. This suggested that the rate of population decline was accelerating. Although the results of these analyses are alarming, I believe that they should be viewed with caution. A number of potential biases exist that could make things look worse than they really are. Probably the biggest concern is that survival rates may be

underestimated if significant undetected emigration occurs. Emigration is probably most problematic with respect to juvenile survival estimates because juveniles disperse considerable distances from their natal sites. It is also likely that some emigration of adults and subadults occurs as well. To better understand population trends of spotted owls, we need more years of data and we need to develop methods to test the magnitude of possible biases in mark-recapture estimates. One way to determine the extent of undetected emigration is to compare survival estimates from radio-marked and color-banded samples. This will be very expensive and time-consuming as it will involve radio-marking large samples of owls.

## DENSITY OF NORTHERN SPOTTED OWLS

FRANKLIN, A.B. *Humboldt State University, Arcata, CA 95521, and Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523.* J.P. WARD. *Department of Biology, Colorado State University, Fort Collins, CO 80523*

Density is a useful measure for estimating population size, monitoring spatial and temporal population trends, and examining mechanisms of population regulation. We examined density estimates for northern spotted owls from 10 study areas on public lands distributed throughout northern California, Oregon and Washington. Density was estimated based on banded individuals on these study areas which ranged from 300 to 1000 $km^2$ in size. Densities on individual study areas were measured over periods ranging from 2 to 8 years. Crude density (number of owls/$km^2$ of total area) ranged from 0.067 to 0.250 owls/$km^2$. We tested hypotheses concerning temporal and spatial trends in density estimates. Trends in density appeared stable while there appeared to be geographic differences. We also evaluated density estimates from public lands with those from private lands managed for timber production. We discuss the problems inherent in accurately estimating density and the utility of density in monitoring programs. We also discuss considerations for estimating density such as sampling design, study area size, and survey effort.

## MANAGEMENT ACTIVITIES ON PRIVATE TIMBERLANDS AND INDUSTRY-SUPPORTED RESEARCH ON NORTHERN SPOTTED OWLS

IRWIN, L.L. *National Council of the Paper Industry for Air and Stream Improvement, P.O. Box 458, Corvallis, OR 97339*

Private timberlands owners in the Pacific Northwest and northern California have developed various approaches to managing their lands relative to legal obligations and voluntary contributions for protecting the northern spotted owl as a federally listed threatened species. Such activities depend upon the size and continuity of the private forests as well as the owner's objectives. Many private owners contract for annual surveys to locate owls, and some companies evaluate nest-site conditions and monitor reproduction success on their lands. Such activities may be used to schedule timber harvests to avoid locations with owls, or they may support development of habitat conservation plans, or HCPs. For example, one company in northern California (Simpson) recently had an HCP approved by the Fish and Wildlife Service for operations on their lands Another company maintains a computerized database of the status of all owls on their lands or on adjacent lands that may affect their operations. The same company is developing a GIS-based process for predicting other owl locations based upon conditions of known sites in managed forests. In many other cases, private companies survey their lands to determine if planned timber operations do not contain spotted owls. Several private companies support research on their lands to learn more about owl habitat requirements, and some have implemented case-history experiments with innovative forestry practices or special techniques (e.g., nest boxes) that may accommodate owls. In addition, a consortium of companies that purchase federal timber support cooperative research on owl populations and habitat relationships. The goal of much of the industry-supported research is to develop new technology that may support forest management alternatives that account for habitat needs of the owl while minimizing costs to wood production. Examples of topics that are being investigated in cooperation with federal agencies will be presented.

## PREDATORS, COMPETITORS, AND MOBSTERS: INTERSPECIFIC INTERACTIONS INVOLVING NORTHERN SPOTTED OWLS

JOHNSON, D.H. *Oregon Department of Fish and Wildlife, 7118 NE Vandenberg Avenue, Corvallis, OR 97330-9446*

Interactions between spotted owls and other wildlife species can be placed into four main groups: prey, predators, competitors, and species which are involved in mobbing behaviors ("mobsters"). This presentation offers a review of the latter three groups and offers results of my recently completed study on spotted owls, great horned owls, and forest landscape patterns in the Central Oregon Cascades. Predators on spotted owls include the great horned owl, goshawk, red-tailed hawk, and common raven. Although Cooper's hawks have been observed in unsuccessful predation attempts, it seems possible that juvenile owls may be taken. Spotted owl mortality caused by avian predation is significant: a query of researchers has indicated that 40% of 91 adult/subadult and 25% of 60 juvenile radio-marked spotted owl deaths were attributable to avian predation; an additional 25% of adult/subadult and 37% of juvenile owls died of undetermined causes; it seems likely that avian predation was involved in at least some of these deaths, as well. The primary competitor of spotted owls is the barred owl. The barred owl outcompetes spotted

owls in several different ways. For example, barred owls are slightly heavier in body mass than spotted owls, take a wider variety of prey, have smaller home ranges which they defend more rigorously, and are more diurnal in their activity patterns. Barred owls seldom "lose" in territorial interactions with spotted owls. Barred owls have continued to expand their range in the Pacific Northwest and now can be found in several hundred locations in Washington, some 260 locations in Oregon, and 17 locations in California. A wide range of species have been observed to mob spotted owls. Mobbing species may frequently make physical contact with spotted owls, ruffling the owl's feathers or, in some instances, knocking spotted owls from their perches. The following species have been observed to mob spotted owls: hermit thrush, Swainson's thrush, varied thrush, Cooper's hawk, black-capped and mountain chickadees, red-breasted nuthatch, rufous hummingbird, dark-eyed juncos, hermit warbler, golden-crowned kinglet, Steller's jay, gray jay, northern pygmy owl, and sharp-shinned hawk. The latter four species have more commonly been observed making physical contact with spotted owls. Great horned owls have been identified as the primary predator on spotted owls. As old-growth forests become fragmented through logging or natural processes, it is hypothesized that great horned owls become established and increase in numbers as this new niche is created. I conducted a nocturnal survey in 1989 and 1990 to locate great horned owls and spotted owls throughout the range of forest fragmentation levels in the Central Cascades of Oregon. Forest fragmentation levels ranged from landscapes (>500 ha in size) containing intact stands of mature/old-growth forest (0% fragmentation) to landscapes containing younger stands with no mature/old-growth forest (100% fragmentation). Six survey visits were made to each of 469 calling stations located along 28 roadside survey routes. Relative abundance for great horned owls and spotted owls was 0.069 and 0.139 owls/road km, respectively. Thirteen habitat/landscape variables within 500-ha circular landscape plots surrounding great horned owl, spotted owl, and random points were assessed. Significant differences existed between great horned owl and spotted owl landscapes for six variables: great horned owl landscapes contained more shrub/forb and shelterwood, less mature/old-growth and mature/old-growth interior habitat, had a higher linear edge-to-mature/old-growth area ratio, and were higher in elevation than spotted owl landscapes. The greatest number of great horned owl responses were associated with landscapes containing 10–20% old forest. Great horned owl responses generally declined with increasing amounts of old forest, and few (11%) great horned owls were detected in landscapes containing ≥70% old forest. The majority (62%) of spotted owls were detected within landscapes containing ≥60% old forest. Spotted owl responses generally declined with declining amounts of old forest and few (7%) spotted owls were detected within landscapes containing ≤20% old forest.

## INVENTORY AND MONITORING PROGRAMS FOR NORTHERN SPOTTED OWLS

LINT, J.B. *Bureau of Land Management, 777 Garden Valley Blvd., Roseburg, OR 97470*

The annual inventory and monitoring of northern spotted owls has become a tradition for many wildlife biologists working for federal and state agencies, universities, private consultants and private timber companies in the Pacific Northwest. Current survey programs are founded on the efforts of biologists that began the search for owls over two decades ago. Pioneer work by Eric Forsman in Oregon and Gordon Gould in California was instrumental in developing and refining standard survey techniques essential to conducting an inventory. In the 1970s, the Forest Service and Bureau of Land Management took the inventory lead by surveying for spotted owl occurrence on lands they administered. This provided the first operational extension of the work of Forsman and Gould. Through the 1970s and early 1980s, agency surveys focused on locating territorial owls to provide basic information for planning timber sales and making land use planning decisions. Survey work for the 1980s decade turned to monitoring owl response to land use decisions and incremental inventory of lands not previously surveyed. During this time period, the use of offered prey called 'mousing' and the implementation of banding added new dimensions to the inventory and monitoring programs. The listing of the spotted owl as a federal threatened species in 1990 accentuated the importance of ongoing work and set in motion intensive efforts by government and private interests to inventory proposed timber sale areas to ensure compliance with the Endangered Species Act. Through inventory and monitoring, knowledge has been gained on the distribution of owls, the relationship of occurrence to forest condition, dispersal movements and reproductive success. The programs, although productive, were not without shortcomings. Some local programs were keyed to finding owls, but lacked clear objectives and plans for data analysis. On a regional scale, poor coordination between agencies, lack of a central data storage and retrieval system and inconsistent formats for data recording were detractions. Fortunately these problems have been identified. The future affords the opportunity to learn from past experience and to establish a single, cooperative spotted owl inventory and monitoring program with common goals and objectives.

## HISTORY OF CONSERVATION PLANNING FOR THE NORTHERN SPOTTED OWL

MESLOW, E.C. *Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, OR 97331-3803*. C.R. BRUCE. *Oregon Department of Fish and Wildlife, 170 NE Vandenberg Ave., Corvallis, OR 97330-9446*. B. MARCOT. *Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, 333 SW First Ave., Portland, OR 97208*

Conservation planning for the Northern Spotted Owl began in 1973 when the bird was given top priority by the newly formed Oregon Endangered Species Task Force. In 1977 the Task Force recommended maintaining 400 pairs on public lands in the state with 300 acres of old forest reserved per pair. Washington (1978) and California (1981) joined in conservation planning efforts. While the acreage reserved per owl pair increased with time, the operative paradigm remained focused on 1–3 pair management units until 1988. In 1989, the Interagency Spotted Owl Scientific Committee was jointly established by the directors of the four federal wildlife/land managing agencies and charged with developing a scientifically credible Northern Spotted Owl management plan. The committee's product provided for a series of 20 pair conservation areas spaced to facilitate dispersal, with intervening "forest matrix" lands managed to provide habitat sufficient to support dispersal. The draft Northern Spotted Owl Recovery Plan utilizes the same basic construct.

### DISPERSAL AND SURVIVAL OF JUVENILE NORTHERN SPOTTED OWLS

MILLER, G. *U.S. Fish and Wildlife Service, 2600 SE 98th Ave., Suite 100, Portland, OR 97266*. E.D. FORSMAN. *USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, 3200 SW Jefferson Way, Corvallis, OR 97331*. D.H. JOHNSON. *Oregon Department of Fish and Wildlife, 170 NE Vandenberg Avenue, Corvallis, OR 97330-9446*

With the federal listing of the spotted owl as a threatened species, highlighted by the Interagency Scientific Committee's Conservation Strategy for the Northern Spotted Owl and the Spotted Owl Recovery Planning process, the importance of juvenile dispersal information has become much more apparent. Prior to 1982, information on the dispersal ecology of juvenile northern spotted owls was limited. Since that time, three general "sources" of study can be identified that have addressed the dispersal topic. (1) In 1982, radiotelemetry studies, using backpack transmitters, were initiated in Washington, Oregon, and California to gather information on juvenile dispersal. Between 1982 and 1985, 6 juveniles in Washington, 32 in Oregon and 23 in California were followed during dispersal. A summary of first-year survival, distance dispersed, and habitat use is provided. (2) Between 1985 and 1987, intensive banding studies were initiated in Washington, Oregon, and California, providing the opportunity to band several hundred juvenile spotted owls. A summary of dispersal distances and survival estimates obtained from the band return (resighting) data is also provided. (3) In 1991, a new radiotelemetry study, using tail-mounted transmitters, was initiated in Oregon and Washington to provide additional information on juvenile survival estimates. Preliminary results from that study for 1991 and 1992 are reported. A comparison of the three sources of information is discussed. An overview of how all of the information on juvenile dispersal and survival has been incorporated into the Interagency Scientific Committee's Conservation Strategy for the Northern Spotted Owl and the Northern Spotted Owl Recovery Planning process is also discussed.

### NORTHERN SPOTTED OWL LITIGATION REVIEW

ROWLAND, M.J. *Institute for Environmental Studies, FM-12, University of Washington, Seattle, WA 98195*

Principal court cases affecting the northern spotted owl will be reviewed. These cases include: *Northern Spotted Owl vs. Hodel*: A suit against the US Fish and Wildlife Service for failure to list the spotted owl under the Endangered Species Act (ESA) and failure to designate critical habitat for the owl. The agency was ordered to reconsider its failure to list the owl, and the owl ultimately was listed. The court also ordered the agency to designate critical habitat. *Seattle Audubon Society vs. Robertson*: A suit challenging the US Forest Service's spotted owl management plan for failure to comply with the National Forest Management Act (NFMA) and the National Environmental Policy Act (NEPA). The court ruled that the Forest Service's plan did not meet the requirements of either law, ordered the agency to prepare another plan, and enjoined further timber sales in spotted owl habitat until a legally adequate plan is in place. *Bureau of Land Management vs. US Fish and Wildlife Service*: A petition by the Bureau of Land Management (BLM) for an exemption for 44 timber sales in Oregon from the requirements of the ESA. The Endangered Species Committee granted an exemption for 13 of the sales, the first exemption ever granted under the ESA after a full hearing. *Portland Audubon Society vs. Bureau of Land Management*· A suit against the BLM for failure to follow NEPA requirements in managing the spotted owl. The court found that the BLM had violated NEPA and enjoined timber sales in spotted owl habitat pending the agency's compliance with NEPA.

### HABITAT USE AND SELECTION BY NORTHERN SPOTTED OWLS

WAGNER, F.F. AND J.A. THRAILKILL. *Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, OR 97331*

The habitat requirements of the Northern Spotted Owl form the crux of the controversy surrounding its conservation. This paper briefly summarizes habitat use and selection studies from the literature and describes one example in some detail. Habitat use and selection for foraging and roosting have been primarily determined from locations of radio-marked owls. These studies compare proportionate use to proportionate availability at the stand condition (broad seral stage) level. The number of studies

that have occurred throughout much of the range of the Northern Spotted Owl often use differing classifications of habitat types. A strong recurring pattern is evident, however. When old growth is classified as a separate habitat type, it is consistently used more than expected. Early seres receive little use and are consistently used less than expected. Mid-seral and mature forest receive ambiguous use: there are relatively few instances of use in excess of availability, but proportionate use appears to increase with successional development/age. A number of observations of Northern Spotted Owls associated with young or managed forest stands have been noted. An example is given for habitat use and selection within a landscape dominated by structurally complex intermediate aged forest and partial-cut older forest. The use of broad seral stages did not differ from the general pattern found in other studies. Compared to unentered old growth, proportionate use was markedly reduced in relatively light partial cuts (salvage) 25 years after entry. Stands in which partial cutting removed 30–40% or more of basal area received little use 10–20 years after entry were consistently used less than expected. We also discuss the need to link habitat use to population response in order to infer habitat quality or suitability.

## ASSOCIATIONS BETWEEN PREY ABUNDANCE, FOREST STRUCTURE, AND HABITAT USE PATTERNS OF SPOTTED OWLS IN CALIFORNIA

ZABEL, C.J. H.F. SAKAI AND J.R. WATERS. *Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, 1700 Bayview Drive, Arcata, CA 95521*

At least 6 hypotheses have been proposed to explain the association between spotted owls (*Strix occidentalis*) and old-growth forests. Here we will address the hypothesis that selection of older forests by spotted owls is related to higher prey abundance in these habitats. Woodrats (*Neotoma* spp.) are the dominant prey of northern spotted owls (*S. o. caurina*) in the Klamath Province of northwestern California. The abundance of dusky-footed woodrats (*N. fuscipes*) was estimated to determine which habitats supported the highest densities. Woodrats averaged over 80 animals/ha in sapling/brushy pole timber stands and <1 woodrat/ha in all other seral stages. Sapling/brushy pole timber stands were seldom used by foraging spotted owls despite the high densities of woodrats that occurred there. However, these stands may be source areas for woodrats that subsequently disperse or move through older stands where spotted owls forage. Several radio-tagged woodrats moved short distances (<52 m) from their nest sites in sapling/pole timber stands into adjacent old-growth stands at night, then subsequently returned to their nests. In a previous study, woodrats were reported to be significantly more abundant at edges of older stands and sapling/brushy stands than in old conifer stands with a hardwood understory or old conifer stands with poor understory development. We examined use of habitat edges by owls by comparing the distribution of distances from edges between owl foraging locations and random locations. Where owls preyed predominantly on woodrats, they foraged significantly closer to edges than expected by chance. Where owls preyed predominantly on flying squirrels, use of edges was not different from random locations. Northern flying squirrels (*Glaucomys sabrinus*) are the primary prey of California spotted owls (*S. o. occidentalis*) on the Lassen National Forest (NF) in northeastern California. Spotted owls on the Lassen NF foraged infrequently in stands that had been shelterwood-logged and undergone intensive site preparation, and they used stands with large-diameter trees and dense canopy cover more than their availability. We tested the hypothesis that flying squirrel density was less in shelterwood-logged and second-growth fir (*Abies* spp.) stands than in nearby old-growth fir stands. Mean flying squirrel density was significantly less in shelterwood-logged than in old-growth and second-growth stands Although squirrel density did not differ significantly between old-growth and second-growth stands, mean density was 40% greater in old-growth than in second-growth stands. Spores of hypogeous fungi sporocarps (truffles) and arboreal lichens were the most frequently observed food types in flying squirrel stomach and fecal samples. We sampled truffles on each grid that was trapped for flying squirrels. Truffle availability (proportion of sample plots on which truffles were found) was significantly correlated with flying squirrel density. Fungus composition varied among the 3 stand types, and more genera were found in old- and second-growth stands than in shelterwood-logged stands. Arboreal lichens were more abundant in old-growth than in second-growth stands. Other habitat variables such as potential nest-site availability and understory cover were less closely associated with flying squirrel density. These data indicate that flying squirrel density was associated with forest structure, and that variation in availability of truffles and lichens explained much of this association The hypothesis that spotted owls select older forests for foraging because prey abundance is higher in these habitats is not supported by data from woodrats, at least for California forests. Woodrats were most abundant in sapling/pole timber stands. These results suggest that where spotted owls in California forests prey on woodrats, they infrequently use younger stands for reasons other than low prey abundance. As suggested elsewhere, high tree densities and homogeneous canopies in second-growth forests may reduce flight maneuverability and the ability of owls to capture prey. However, where woodrats are the dominant prey of spotted owls, silvicultural procedures that maintain or enhance woodrat populations adjacent to suitable spotted owl habitat may benefit spotted owls. This hypothesis needs to be tested. Flying squirrel density patterns were consistent with spotted owl habitat use patterns, at least between shelterwood-logged and old-growth fir stands. Results were less clear for even-aged second-growth

stands. Because such stands are rare on the landscape, we were unable to adequately examine how frequently they are used by spotted owls. Flying squirrel density was greater in old-growth than in second-growth stands, but density varied greatly among stands. This problem needs further research.

## BURROWING OWL SYMPOSIUM

ORGANIZER: JEFFREY L. LINCER, *Biosystems Analysis, Inc., 13220 Evening Creek Drive South, Suite 119, San Diego, CA 92128*

### ECOLOGY OF THE BURROWING OWL IN PAMPEAN AGROSYSTEMS OF ARGENTINA

BELLOCQ, I. *Faculty of Forestry, University of Toronto, 33 Willcocks St., Toronto, Ontario, Canada M5S 3B3*

A general approach to the ecology of Burrowing Owls in Pampean agrosystems of Argentina was made: 1) to record basic information on habitat use, food habits, hunting habitat, differential predation on rodents, feeding strategy, mortality factors, and breeding biology; 2) to examine the reproductive success and needs of conservation; and 3) to examine regulatory effects on rodent populations. The Burrowing Owl is the most abundant owl in Pampean agrosystems. It is a generalist predator and its diet strongly depends on the availability of alternative prey. Borders of cultivated fields are the most common hunting habitats, where they showed differential predation on rodent species. The Burrowing Owl showed a sigmoidal functional response to the abundance of rodent populations; and this might contribute to the biological control of rodents in Pampean agrosystems. Nests are built in areas with relatively low disturbance. Mean clutch size was $4.8 \pm 1.2$ eggs, mean hatching per nest was $3.5 \pm 2.4$, and reproductive success was as low as 0.3 fledges per brood. Brood size affected growth of chicks. Main mortality factors of eggs were agricultural practices and predation, while illnesses and human predation were the main mortality factors of chicks. The low reproductive success may negatively influence the near future of Burrowing Owl populations in Pampean agrosystems. More studies should be done to provide more information (especially on mortality factors and population dynamics) before considering possible strategies for management and conservation.

### THE BURROWING OWL IN THE AMERICAS: ITS TAXONOMY AND HISTORICAL DISTRIBUTION

CLARK, R.J. *Department of Biology, York College of Pennsylvania, York, PA 17405-7199*

The Burrowing Owl was originally placed in the Genus *Strix* (1782) and then placed in the Genus *Athene* (1822) followed by being separated into a monotypic Genus *Speotyto* in 1842. It was later again included within *Athene* (1967–88) and again suggested as being properly placed in the monotypic Genus *Speotyto* in 1990. Evidences for these recommendations are reviewed. There are 18 commonly recognized geographic races of *Athene cunicularia* with two races having become extinct in historical times The geographic distribution of these races is also reviewed The above discussions are based on the literature, and an extensive bibliography is presented.

### RESULTS OF THE 1991 CENSUS OF BURROWING OWLS IN CENTRAL CALIFORNIA: AN ALARMINGLY SMALL AND DECLINING POPULATION

DESANTE, D.F., E. RUHLEN, S. AMIN AND K.M. BURTON. *The Institute for Bird Populations, P.O. Box 1346, Point Reyes Station, CA 94956-1346*

The Institute for Bird Populations, with the help of volunteers from 13 local Audubon Society chapters and ornithological organizations, conducted a census of Burrowing Owls in the San Francisco Bay Area and the central part of California's Central Valley during the period May 15–June 30, 1991. A random stratified sample of 198 of the 1792 5-km by 5-km UTM blocks in this 43 425-$km^2$ census area, along with 82 additional blocks that were not randomly chosen but were thought to contain breeding owls sometime during the preceding decade, were censused. A total of 328 pairs of owls was found at a total of 264 breeding locations in 73 blocks. These data suggest that the total breeding population of Burrowing Owls in the census area may be as low as 925 pairs, and that up to 69.4% of the 504 previously suspected breeding pairs and 65.6% of the 355 previously suspected breeding locations may have disappeared during the past decade. The data also suggest that the disappearance rate was greater in the Bay Area than in the Central Valley, and that the disappearance rate in both regions, but especially in the Central Valley, is accelerating. Loss of breeding habitat appears to be one major cause for this pronounced population decline. The fact that the number of breeding pairs per breeding location also appears to be declining, particularly in the Central Valley, suggests that other factors may also be contributing to the decline. We suggest that unless concerted efforts to reverse this population decline are initiated quickly, Burrowing Owls may be extirpated from central California within about 50 years. Possible errors in these results, and methods for determining the extent of these errors in the 1992 and 1993 censuses, are discussed.

### SITE FIDELITY IN BURROWING OWLS

FEENEY, L.R. *1330 Eighth Street, Alameda, CA 94501*

An effort to dislocate a pair of Burrowing Owls in San Joaquin County, California from a development site during the early winter of 1991–92 and subsequent monitor-

ing revealed strong site fidelity of the birds. Site loyalty in Burrowing Owls has been exhibited in other San Francisco Bay Area relocation projects as well. Examples of Burrowing Owl site fidelity during dislocation or relocation efforts are presented and discussed raising questions regarding these efforts as an effective method of removing Burrowing Owls from proposed development or other sites. A comparison is made between the Burrowing Owl and other bird species, whose tenacity to nesting and wintering sites has been studied with results available in the literature, in order to relate possible implications of site fidelity in Burrowing Owls. With a growing concern for decreasing populations of Burrowing Owls, relocation has become one method of mitigating habitat losses. Site fidelity is an important consideration for developing successful mitigation proposals.

## Ecological Considerations for Management of Breeding Burrowing Owls in the Columbia Basin

GREEN, G.A. *EBASCO Environmental, 10900 NE 8th Street, Bellevue, WA 98004.* R.G. ANTHONY. *Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, OR 97331*

Burrowing Owls inhabiting the Columbia Basin of Oregon and Washington rely largely on badgers to excavate nest burrows; however, badgers are also a major predator of Burrowing Owl nests. To avoid badger predation through early detection, Burrowing Owls in the Columbia Basin select burrows with good horizontal visibility provided by surrounding short vegetation or, when the average vegetation height is >5 cm by elevated perches. Burrowing Owls will also line their nest burrows with livestock dung, if available, presumably to mask odors of nest occupants from mammalian predators. Burrowing Owls also select sites characterized by a high percentage (40–50%) of bare ground, where prey (*Heteromyid* rodents and ground-dwelling arthropods) populations are presumably high. Abandonment of nest sites tends to occur when distances between nest sites are less than 110 m, an important consideration when placing artificial nest boxes. Furthermore, small nest boxes can become overcrowded by growing broods, often forcing movements of all or part of the brood to auxiliary burrows, increasing the susceptibility of nestlings to predation or abandonment. Therefore, several aspects of Burrowing Owl nesting ecology, including predator avoidance, intraspecific competition, prey selection, and brood development, should be understood before designing a program for managing nesting habitat.

## Recovery Plan for the Burrowing Owl in Canada

HJERTAAS, D.G. *Saskatchewan Natural Resources, 3211 Albert Street, Regina, SK, Canada, S4S 5W6*

The population of Burrowing Owls nesting in Canada has been in decline since the mid-1900s. The Burrowing Owl, extirpated from British Columbia, now being reintroduced, is listed as endangered in Manitoba and has experienced major declines in Alberta and Saskatchewan. Habitat loss is considered a significant cause of decline although elevated mortality from pesticides, vehicle collisions and unknown causes is also a major problem. The National Population goal is set at 2700 breeding pairs. Principal management actions recommended in the plan and some results of these efforts will be discussed in three priority groups. Priority 1: 1) Management to reduce mortality and increase productivity on breeding grounds. 2) Protection and management of nesting habitat. Priority 2: 3) Population monitoring. 4) Population management on migration and wintering grounds. Priority 3: 5) Eliminate negative effects of pesticides. Priority 4: 6) Release programs.

## Burrowing Owls, Biodiversity, and Bombs

JAMES, P.C. *Saskatchewan Museum of Natural History, Wascana Park, Regina, SK, Canada S4P 3V7*

The Burrowing Owl is a species of the grasslands and, as such, is coming under increasing pressure from agricultural activity. While not yet an endangered species, it is symptomatic of the increasing global assault against biodiversity by people. The threats to biodiversity are numerous, but all result from the continuing non-sustainable use of the planet's resources. Only 7% of the world's military budget is needed to reverse this. As students of biodiversity, biologists must also become champions of biodiversity.

## Operation Burrowing Owl in Saskatchewan: The First Five Years

JAMES, P.C. *Saskatchewan Museum of Natural History, Wascana Park, Regina, SK, Canada S4P 3V7*

Habitat loss is a serious problem for prairie wildlife in Canada. Operation Burrowing Owl was initiated in 1987 as a private stewardship program to protect owl habitat through landowner recognition, to increase awareness of the owl as a threatened species, to conduct an annual census of the Saskatchewan population, and to place nest boxes in areas to facilitate research and breeding. Landowners with owls sign a voluntary agreement to preserve the nesting site for five years. In return, they receive a gate sign, an annual newsletter, and a survey form on which to report the number of owls. As of 1991, the program had a membership of 499, with 647 pairs of owls protected on over 40 000 acres of habitat. However, despite this protection, the population has declined rapidly with 46% of the members no longer having owls on their property. While Operation Burrowing Owl may not have halted this decline, it has considerably raised the awareness of this and other endangered species among farmers.

### PARAMETERS OF A DECLINING BURROWING OWL POPULATION IN SASKATCHEWAN

JAMES, P.C. *Saskatchewan Museum of Natural History, Wascana Park, Regina, SK, Canada S4P 3V7*

A declining population of Burrowing Owls was studied on the heavily cultivated Regina Plain of Saskatchewan from 1986 to 1992 by trapping adults and chicks. Information is presented on age, breeding, mortality, breeding dispersal, natal dispersal, and mate fidelity in the population. In no year did chick production offset annual adult mortality, hence, the observed decline. Chick production seemed to be consistent with historical records suggesting that mortality in the population is currently too high.

### DEMOGRAPHY AND POPULATION DYNAMICS OF THE BURROWING OWL

JOHNSON, B.S. *2321 Evenstar Lane, Davis, CA 95616*

I used deterministic, age-structured analytic models to 1) examine the demographic causes of projected and observed declines in the size of a color-marked, Burrowing Owl population, and 2) predict persistence time for the population. Estimates of Burrowing Owl demographic parameters were calculated from direct observations and from genetic analyses of reproductive success, and represented a range of possible values. Comparison of theoretical expectations (based on actual demographic traits) with the real dynamics of the population over ten years showed that the population declined to reproductive extinction in half the time predicted by the models. This discrepancy suggests that stochastic variation in demographic traits, possibly caused by weather, along with stochastic and deterministic changes in genetic structure, also contribute to the dynamics and persistence of Burrowing Owl populations.

### REPRODUCTIVE SUCCESS, RELATEDNESS, AND MATING PATTERNS IN A COLONIAL BIRD, THE BURROWING OWL

JOHNSON, B.S. *2321 Evenstar Lane, Davis, CA 95616*

I used DNA fingerprinting to characterize patterns of mating, genealogies, and reproductive success in a wild population of color-marked, Burrowing Owls in Davis, California. This study was designed to evaluate whether behavioral assessments of individual reproductive performance and mating system agreed with estimates obtained by genetic analysis, and to measure the degree of genetic relatedness in a highly social resident aggregation of Burrowing Owls. The data revealed important discrepancies between patterns suggested by inference and those documented by direct genetic measurement. DNA fingerprints showed that in 20% of cases, genetically determined parent-offspring relationships and those suggested by direct behavioral observations disagreed. These differences were due to nestling movements and brood mixing, extra-pair fertilizations (which resulted in at least 5–10% of offspring), polygamy, and possibly intraspecific brood parasitism. These previously undocumented aspects of Burrowing Owl mating biology collectively resulted in alloparenting by 37% of the adult owls. Most of these behaviors can be expected to enhance within-population genetic heterogeneity and contribute to variation in individual reproductive success. However, analysis of multilocus fingerprint similarity suggested that the Davis Burrowing Owl population is inbred due to small deme size rather than nonrandom mating. Because inbreeding enhances selection between groups at the expense of opposing selection within groups, it can be expected to counter the effects of brood mixing and unequal reproductive contributions, and facilitate the evolution of Burrowing Owl social behavior.

### SURVEY TECHNIQUE FOR BURROWING OWLS IN BADLANDS NATIONAL PARK, SOUTH DAKOTA

MARTELL, M., J. NIBE AND P.T. REDIG. *The Raptor Center at the University of Minnesota, 1920 Fitch Ave., St Paul, MN 55108*

Accurate counts of raptor populations are necessary for successful management, research and conservation programs. A method to efficiently and accurately make repeatable counts of breeding Burrowing Owls (*Athene cunicularia*) has not been available to wildlife managers. We attempted to develop such a census technique for Burrowing Owls in Badlands National Park. During June and July (incubation and hatching season in this area) of 1991 transects were established on five separate prairie dog towns within the park. Points, 300 m apart along the transect, were visited for ten minutes and owls were looked and listened for. Surveys were repeated an average of five times. In 1992, using the same techniques, surveys were repeated on the two towns on which we found owls in 1991, and were done twice on eight other towns in the park. Data were analyzed using the area occupied method We were able to establish a census technique for Badlands National Park which can be carried out by Park biologists with a minimum of training. Results can be compared between years, and form a framework for management of Burrowing Owls in the Park. We believe that this technique has application to other areas of the country where Burrowing Owls nest in semi-colonial situations.

### REPRODUCTIVE ECOLOGY OF THE BURROWING OWL, *ATHENE CUNICULARIA FLORIDANA*, IN DADE AND BROWARD COUNTIES, FLORIDA

MEALEY, B.K. *Falcon Batchelor Bird of Prey Center, Museum of Science, 3280 South Miami Avenue, Miami, FL 33129*

During 1988 and 1990, a reproductive study of the ecology of the Burrowing Owl was conducted to determine sea-

sonality and reproductive success at the Miami International Airport and private residences in Dade and Broward counties, Florida. Reproductive data for each of the three years (1988–90) reveal a higher reproductive success rate (54%) for 1990 than 1989 (40%) and 1988 (40%). Owls using previously used burrows had a higher success in fledging young (63%) than newly excavated burrows (19%). T-tests were conducted on several appendage measurements of male and female owls to determine sexual dimorphic traits. Metatarsus lengths of males and females were different ($t = 2.36$, $P = 0.02$). As of 1990, 197 owls had been banded in the study areas. In 1989, 75% and in 1990, 83% of the banded adults were found on the same territory. Only four of 129 banded nestlings have been reencountered in the study sites. The owls' nesting sites are primarily located in residential areas. Management will involve educating home owners concerning landscaping techniques and their effects on the Burrowing Owl population.

## MATE AND TERRITORY FIDELITY AND NATAL DISPERSAL IN AN URBAN POPULATION OF FLORIDA BURROWING OWLS (*ATHENE CUNICULARIA FLORIDANA*)

MILLSAP, B.A. *Nongame Wildlife Program, Florida Game and Fresh Water Fish Commission, 620 S. Meridian St., Tallahassee, FL 32399-1600.* C. BEAR. *Audubon Society of Southwest Florida, 1619 SW 33rd Terrace, Cape Coral, FL 33914*

From 1986 to the present we studied an urban population of Florida Burrowing Owls on a 32 $km^2$ study area in Cape Coral, Lee County, Florida. This paper uses data collected from 1987 to 1989. During this period, the number of breeding pairs varied from 129 to 190; a total of 617 nesting attempts was monitored. In 1987 and 1988, 476 owls, about 25% of breeding adults and 20% of nestlings, were banded. All banded breeding adults were identified in subsequent years, and 207 individuals were reencountered during the study period. Reencounter rates between years averaged 68% for adult males, 58% for adult females, and 20% for one-year-old owls. Reencountered adults typically remained on the same territory between years (87% of males and 69% of females). Nearly all pairs (95%), where both adults survived between years, remained paired. Natal dispersal distances averaged 81.4 m for males and 531 m for females. Data from additional years will be included in the oral presentation.

## DIURNAL AND CREPUSCULAR/NOCTURNAL FORAGING AND BEHAVIORAL DIFFERENCES OF THE WESTERN BURROWING OWL

PEZZOLESI, L.S.W. *Department of Range and Wildlife Management, Texas Tech University, Lubbock, TX 79409.* D.L. PLUMPTON. *U.S. Fish and Wildlife Service Field Office, Rocky Mountain Arsenal, Bldg. 613, Commerce City, CO 80022.* R.S. LUTZ. *Department of Range and Wildlife Management, Texas Tech University, Lubbock, TX 79409*

During the nesting seasons of 1990 and 1991, diurnal time budgets of Burrowing Owls (*Speotyto cunicularia hypugaea*) in Colorado were studied. In 1992 a night-vision scope was used to collect comparable observational data during darkness. Due to the change in foraging responsibility of having young to feed, diurnal and crepuscular/nocturnal behaviors were split into prehatch and posthatch seasons and compared separately. We used foraging theory predictions to also investigate foraging behavior between these two periods. Preliminary investigation of prehatch behaviors indicated comfort movements (i.e., preening, stretching, etc.) ($P = 0.005$), resting ($P = 0.009$), and alert ($P = 0.006$) were greater diurnally, while out-of-sight ($P = 0.002$) and feeding ($P = 0.004$) were more frequent during crepuscular/nocturnal hours. During the posthatch period, burrowing owls locomoted more nocturnally ($P = 0.0002$) and performed comfort movements more frequently diurnally ($P = 0.004$). Additionally, when the sexes were analyzed separately, females rested ($P = 0.013$) more during daylight in the posthatch period. Several predictions of foraging behavior were based on central place foraging theory: foraging bouts when an individual returned with a mammal should be longer than those when it returned with an insect, males should have longer foraging bouts than females, and males should capture proportionately more mammals than insects than females capture. As predicted, foraging bouts when an owl returned with a small mammal (mean = 327 seconds) were longer ($P = 0.0001$) than those resulting in an insect capture (mean = 205 seconds). Male foraging bouts (mean = 257 seconds) are also longer ($P = 0.0001$) than female (mean = 193 seconds). Furthermore, males take more small mammals (15%) proportionally than females (2%) take ($P < 0.05$). The information presented here has several management implications. First, males capture more small mammals than females, and both sexes capture a relatively large number of insects. Consequently, both insect and small mammal prey bases are important factors in Burrowing Owl nesting activity. Secondly, the foraging theory predictions examined held true. These predictions can now be taken into consideration when examining prey populations in relation to their location and distance from the Burrowing Owl nesting burrow.

## BURROWING OWLS IN MAPIMI, MEXICO

RODRIGUEZ ESTRELLA, R. AND A. ORTEGA RUBIO. *Centro de Investigaciones Biologicas, Div. Biol. Terr., Apdo. Postal 128, La Paz 23000 B.C.S. Mexico*

Burrowing Owls (*Athene cunicularia*) are threatened throughout much of their North American distribution. This owl has declined due mainly to habitat destruction

or modification and to the control of burrowing mammals. We examine the nest site characteristics and reproductive success of Burrowing Owls during two breeding seasons in the southern portion of the Chihuahuan desert. From March to July 1985 and 1986 owls and their burrows were located searching an area of 20 000 ha using stand condition maps of the Mapimi Biosphere Reserve (Durango, Mexico; 26°29′–26°52′N, 103°58′–103°32′W). Nesting densities were 0.15 pairs/km$^2$ and 0.12 pairs/km$^2$ in 1985 and 1986 ($N = 29$ and $N = 23$ pairs, respectively). No difference in nesting success was found in both years (60%) and productivity was also similar (2.19 and 1.63 young/successful nest, 1.52 and 0.90 young/attempt in 1985 and 1986, respectively). Burrow re-use was 55.2%. PCAs and correlation tests show that a mixture of *Prosopis*, *Larrea* and *Hilaria* in the vegetation of the "playas" is important in the distribution of the nests and is highly correlated with nesting success. Nests located at the *Prosopis-Hilaria* grassland vegetation produced almost 50% of the total fledglings ($\chi^2 = 7.62$; df = 1; $P < 0.01$). The highest number of fledglings is produced in kangaroo-rat and fox burrows, burrows located under grassland and clay-sand soils. The mean distances between adjacent owl nests were over 1 km, but ranged from 30 to 4167 m (mean = 1287 ± 98). The distribution of active nests in both years indicates a tendency toward regular spacing of breeding pairs. The grassland vegetation type is the habitat with more potentialities to be used by human beings in the zone as cattle raising is the most important economic activity. The management plan of this Biosphere Reserve must consider the negative effects of cattle raising on the burrows functioning as potential nests for Burrowing Owls proposing that cattle densities on the owl breeding areas be moderate.

### IS THE DENSITY OF BURROWING OWLS BREEDING IN ALBERTA LIMITED BY HABITAT?

SCHMUTZ, J.K. *Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 0W0*

To evaluate whether the density or distribution of breeding pairs of Burrowing Owls (*Athene cunicularia*) is determined by habitat availability, I recorded the location of agricultural fields, the density and distribution of native vegetation, and the abundance of burrows and "grasshoppers." The results were compared between nest sites and control sites located 1 km north of each nest site. If the results of this study are extrapolated to the population level, a conclusion that emerges is that in this particular area, where the dominant land use is grazing with 15% cultivation, Burrowing Owls are not limited in number or distribution by habitat availability.

### OBSERVATIONS, RESIGHTINGS, AND ENCOUNTERS OF REHABILITATED, ORPHANED, AND RELOCATED BURROWING OWLS

SCHULZ, T.A. *6010 Acorn Court, Foresthill, CA 95631*

This paper describes data on the results of banded, rehabilitated, orphaned, and/or relocated Burrowing Owls Between 1981 and 1988, 16 injured or orphaned Burrowing Owls were banded and released in occupied or unoccupied burrows within an established colony on the University of California, Davis (UCD) campus in order to augment a declining population and to observe and document post-release behavior, survival, and mortality. A total of nine HY owls were fostered, and five were encountered or resighted. Two were encountered three and five days post-release due to collisions with large windows near the release site. One owl encountered 12 days post-release was retrapped at the release site. Two other fostered owls were resighted up to 28 days and 34 days post-release. These two utilized both the original release burrow and satellite burrows within 30 yards. A total of seven adult rehabilitated owls was released with one encounter 80 days post-release, dead due to collision with a vehicle approximately 200 yards from the release site. Another total of seven Burrowing Owls was relocated at distances ranging from 0.5 miles to 30 miles. Both of the two adult owls relocated at 0.5 miles on the UCD campus in December 1981 were later encountered at 426 days (dead due to collision with a vehicle) and 1310 days (retrapped near the release site). In June 1991, six other Burrowing Owls were relocated 15 and 30 miles away from a development site in Sacramento. Of the six relocated owls, five were observed between 10 and 49 days post-release. One adult female observed 10 days at the relocation site returned 15 miles to its original territory, arriving 32 days post-release. In another successful short distance relocation project, a technique using a one-way burrow exit precluded the necessity for trapping. All owls relocated themselves to artificial burrows previously placed 50 yards away. These data suggest that while some Burrowing Owls develop a strong fidelity to a relocation site, others tend to move on to other habitats after a period of adjustment at a relocation site.

### COMPARISON OF SELECTED ASPECTS OF BURROWING OWL ECOLOGY AT TWO SITES IN SANTA CLARA COUNTY, CALIFORNIA

TRULIO, L.A. *Department of Geography and Environmental Studies, San Jose State University, San Jose, CA 95192-0116*

A two-year study was begun in January 1992, which investigates the effect of land use at Moffett Naval Air Station on the ecology and behavior of the base's western Burrowing Owl (*Speotyto cunicularia hypugaea*) population. These preliminary data compare reproductive and burrow choice parameters at Moffett and an adjacent site, Shoreline, a regional park. In August 1992, at least 37 adults (18 pairs and one single bird) lived on approxi-

mately 900 acres of land at Moffett. Of 15 pairs regularly observed, 73% of these (or 11 pairs) had a minimum of 27 chicks total, for an average of 2.5 chicks per brood, observed within three weeks of emergence. Shoreline had 23 owls (11 pairs and one single bird) living on 750 acres. Nine pairs of owls at Shoreline were regularly observed and seven of these (78% of pairs) had at least 21 chicks; the average of 3.0 chicks per brood was not significantly different from Moffett ($t = -0.975$; $df = 15$; $P = 0.05$). Observations indicate a difference in primary burrow location between Moffett and Shoreline birds. At Moffett, 15 of 19 primary burrow sites were located adjacent to or under a piece of cement or a fence, while four were located in a field without these features. Only one of the owl pairs at Shoreline chose burrows under cement or a fence, although such sites were available. Factors influencing this difference may be useful for enhancing burrowing owl habitat and are considered.

## GENERAL SCIENTIFIC PROGRAM

CHAIR: MARK V. STALMASTER, *Stalmaster and Associates, 209 23rd Avenue, Milton, WA 98354*

### ORANGE-BREASTED FALCON REPRODUCTION, DENSITY, AND BEHAVIOR IN NORTHERN CENTRAL AMERICA

BAKER, A.J. *P.O. Box 2492, Gig Harbor, WA 98335*. D.F. WHITACRE. *The Peregrine Fund Inc., 5666 W. Flying Hawk Lane, Boise, ID 83709*

The Orange-breasted Falcon (*Falco deiroleucus*) is known to occur in New World tropical forests from northern Argentina, Paraguay, and Bolivia north through Central America to Guatemala and southeast Mexico. As part of The Peregrine Fund's Maya Project, I searched for and studied nesting pairs of *F. deiroleucus* in Belize and Guatemala from mid-February through mid-June 1992. Fifty-four days were spent exploring areas for new pairs and 48 days observing at known sites. Of 13 sites (new and known from previous years) in Belize and Guatemala, 12 were visited, and 10 were occupied by Orange-breasted Falcons. Of the 10 pairs, five pairs fledged eight young with broods of one to three, one pair failed, and the productivity of four pairs is unknown. Eight of the 10 pairs occupied cliffs above either rivers or standing water surrounded by unaltered forest. Of the remaining two, one used a dry limestone sinkhole and the other an emergent Palm (*Orbignya cohune*). In two areas of Belize, groups of three pairs occurred inside diameters of 10 km, including two facing pairs <1 km apart. Nuptial behavior was well underway by mid-February and eggs were laid in the first half of March. Behavior observed included courtship, mounting, nest scraping, prey exchanges, caching, hunting, interspecific territoriality, and mock fighting between recently fledged siblings. The virtually unknown *F. deiroleucus* is certainly under pressure; a fast-growing human population, logging, slash-and-burn agriculture, and livestock grazing have and will continue to push these falcons out of suitable nesting areas. Learning more about their habitat and prey requirements will help in attempts to preserve forests and falcons in the Neotropics.

### AMERICAN KESTRELS AT MCGILL UNIVERSITY: THE FIRST TWENTY YEARS

BIRD, D.M. *Avian Science and Conservation Centre of McGill University, 21,111 Lakeshore Road, Ste. Anne de Bellevue, Quebec, Canada, H9X 3V9*

Beginning with 10 pairs of captive kestrels in 1972–73, the McGill colony has been established at roughly 300 pedigreed birds. The kestrels have been used to develop procedures for artificial insemination (including frozen-thawed semen), artificial incubation, and forest renesting. A model involving *Trichinella pseudospiralis* and the kestrel has been used successfully to determine the impact of parasite load on health, reproductive performance, mate choice, and foraging behavior. Several studies have focused on endocrinology, specifically androgens, estrogens, corticosterone, luteinizing hormone, and more recently, growth hormone. Toxicological research has been aimed at DDE, PCBs, mirex, fluoride, aluminum, and fenthion. The above studies, as well as newly initiated work on paternity and inbreeding, will be summarized.

### NORTHERN GOSHAWK DIETS IN PONDEROSA PINE FORESTS ON THE KAIBAB PLATEAU

BOAL, C.W. AND R.W. MANNAN. *School of Renewable Natural Resources, Biological Sciences East, University of Arizona, Tucson, AZ 85721*

Little dietary information is known for Northern Goshawks (*Accipiter gentilis*) in the southwest. We conducted 1539 hours of direct observation at 20 active goshawk nests in ponderosa pine forests on the North Kaibab Ranger District, Arizona, 1990–92. A total of 384 prey deliveries was recorded, 306 were identified to species, 63 were identified to class, and 15 were unidentifiable. Mammals and birds made up 75.1% and 24.9% of the items delivered, respectively. Golden-mantled ground squirrels (*Citellus lateralis*) and cottontail rabbits (*Sylvilagus* spp.) were the most common mammalian prey species, constituting 41.1% of all identified prey. Steller's jays (*Cyanocitta stelleri*) and northern flickers (*Colaptes auratus*) were the most common avian prey species and constituted 16.0% of all identified prey. Mean prey delivery rate was 0.25 deliveries per hour.

### EFFECTS OF THE EXXON VALDEZ OIL SPILL ON BALD EAGLES

BOWMAN, T.D. *U.S. Fish and Wildlife Service, P.O. Box 768, Cordova, AK 99574*

In March 1989, the tanker *Exxon Valdez* ran aground and spilled more than 11 million gallons of crude oil, fouling shorelines from Prince William Sound to the Alaska Peninsula. About 8000 bald eagles inhabit that area. A 3-year study was initiated soon after to assess damages to bald eagles. Specific objectives were to determine effects of the spill on bald eagle reproduction and survival of adults and fledglings, conduct population surveys to assess population response, and examine eggs, prey, and blood for evidence of hydrocarbon exposure. Greatest damages to bald eagles occurred in 1989 and were manifested by direct mortality of an estimated 900 bald eagles throughout the spill area (about 10% of the population), and significantly reduced reproduction. Contamination of eggs and prey remains confirmed exposure to hydrocarbons. Reproductive failures were directly related to the extent and intensity of shoreline oiling near nests, but seem to have been limited only to Prince William Sound. The lack of observed reproductive failure in other areas was likely due to the timing of arrival, or decreased toxicity, of crude oil as the slick moved westward along the coast. Bald eagle reproduction in Prince William Sound rebounded in 1990. Population surveys in Prince William Sound did not show a significant decrease in numbers of bald eagles from 1989 to 1991, although confidence limits on estimates ranged from 13% to 30%. Survival was high for eagles radiotagged 4–5 months after the spill, and there were no differences in survival between birds from oiled and unoiled areas. The observed responses suggest that the oil spill had only a short-term effect on bald eagle populations. A population model of bald eagles in Prince William Sound indicates that the population was increasing before the spill at a rate of about 2% per year. The cumulative effects of the direct mortality and reduced productivity in 1989 will set the population in Prince William Sound back by 3–4 years, but population growth should continue.

### USDA, Forest Service Goshawk Management Strategy

BOYCE, JR., D.A. *USFS Wildlife and Fisheries, 517 Gold Avenue SW, Albuquerque, NM 87102*

The current political atmosphere surrounding goshawks is described from a national perspective. The distribution and numbers of breeding goshawks on Forest Service lands throughout the western United States are discussed. Decisions and policy established at the regional and national level are described. The Forest Service challenge of meeting its Multiple-Use resource mandate and maintaining viable populations of Goshawks is discussed. Because of their extensive breeding range (east coast to west coast) and large territory size (about 10 square miles), the management strategies developed for goshawks have the potential to profoundly change Forest Service management practices throughout the country.

### Introducing the International Raptor Migration Atlas Project (IRMAP)

BRETT, J., L. GOODRICH, C. VIVERETTE AND K.L. BILDSTEIN. *Hawk Mountain Sanctuary, Route 2, Box 191, Kempton, PA 19529-9449*

We introduce the twin concepts of 1) a registry of sites of global significance to migrating raptors and 2) an international raptor migration atlas. The registry, loosely modeled after the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (the so-called Ramsar Convention) and the Western Hemisphere Shorebird Reserve Network, is designed to champion the conservation of migratory birds of prey and their essential habitats. (Possible criteria for registry sites are offered for discussion purposes.) The atlas is designed to provide information needed to determine which sites should be listed as registry candidates. The project is housed at Hawk Mountain Sanctuary and is endorsed by the International Council for Bird Preservation and the World Working Group for Birds of Prey and Owls. A panel of internationally recognized authorities serves as a technical advisory board. Our paper presents preliminary, but significant, results of an initial international mailing and literature review of sites hosting large numbers of migrating raptors. IRMAP is gathering information on the geographic locations, environmental characteristics, monitoring efforts, and current threats to raptors associated with points of concentration along the world's major migratory corridors. To date, hundreds of sites encompassing six continents, many of which were heretofore unpublished, have been submitted. When completed, atlas data and registry candidates will be presented in a major publication that will provide an unprecedented global overview of raptor migration ecology and conservation. An appeal is made for information on sites that are not yet included in our database.

### Variation in Spotted Owl Nest Site Characteristics Within the Wenatchee National Forest

BUCHANAN, J.B. *Washington Department of Wildlife, 600 Capitol Way North, Olympia, WA 98501.* L.L. IRWIN. *NCASI, 720 SW Fourth Street, Corvallis, OR 97339*

Spotted Owls (*Strix occidentalis caurina*) nest in a broad range of forest stand conditions in the Wenatchee National Forest (WNF). Nearly half of the known nests occur in even-aged patches or stands 65–135 years old, and 21% of the nest sites were partially harvested several decades prior to our study. A predictive model developed to distinguish between nest and random sites at the stand level correctly identified 70% of the study sites. Diagnostic evaluation of the model indicated that the low classification rate reflected variation in habitat conditions within the WNF. To identify factors that could improve the model, we developed pairs of predictive models based on north-

and south-facing slopes and on sites with and without evidence of previous partial harvest. The aspect and harvest models correctly classified 65–93% of the sites; however, none of the models were stable, as determined by cross-validation. Following this we examined variation among nest sites within the WNF by comparing mean habitat values among 4 of the 5 Fire Management Analysis Zones (FMAZ) identified by the U.S. Forest Service for fire control purposes. The FMAZ areas were defined primarily in terms of topography, annual precipitation, and estimates of fuel loading and fire frequency. We found significant differences among the FMAZ for nearly half of the 60 habitat features we compared at nest sites. It may be possible to develop predictive models within each FMAZ using the original or other models. For example, the harvest model (with a larger sample) may be useful to researchers and managers who wish to conduct adaptive management experiments in stands managed for timber and/or fire protection. The use of such models within the FMAZ framework would likely be more powerful and allow better management throughout the region.

## BLACKFLY (*SIMULIUM* SPP.) INDUCED MORTALITY OF RED-TAILED HAWK NESTLINGS IN NORTHWEST WYOMING

CAIN, S.L., R.N. SMITH AND J.R. DUNK. *Grand Teton National Park, P.O. Box 170, Moose, WY 83012*

Red-tailed hawk productivity monitoring in Grand Teton National Park, Wyoming during 1990 and 1991 indicated a high proportion of nests were failing when nestlings were 2–4 weeks old. Dead nestlings found within and under nests, when adult pairs were still defensive and prey was abundant in the nest, suggested parasitism as a potential cause of mortality. In 1992, 20 occupied red-tailed territories were monitored throughout the nesting season. Eggs were laid at 18 territories and hatched at 13. Infestations of blackflies (*Simulium* spp.) were documented at all nests visited ($N = 12$) between 4–9 June when nestlings were from 3 to 20 days old. Infestation levels among nests varied from tens to thousands of flies. Flies primarily sucked blood from areas around the eyes, cere, auricular opening, and chin, but also burrowed through the down anywhere on the body. Fly activity decreased substantially during periods of cold weather. Complete brood mortality, as a result of dehydration and/or nestlings being driven from their nests, was documented at 4 nests. Circumstantial evidence indicated that blackflies caused nestling or post-fledgling mortality at 2 additional nests. Dead nestlings found at 2 more nests located late in the nesting season implicated blackfly infestations as well. In total, blackflies were believed to have caused mortality at 8 of 15 (53%) nests known to hatch young. Nestling mortality occurred in as few as 7 days after infestations began. Avian blackfly infestations and associated mortality have rarely been reported. We believe blackfly infestations may be locally important sources of red-tailed hawk mortality, especially if they are chronic, rather than acute, as has been suggested by others. Furthermore, because of 1) their small size, 2) their ephemeral presence at the nests, and 3) the wide range of nestling ages at which mortality occurs, blackfly infestations are probably undetected during many standard productivity surveys based on 2–3 nest visits during the nesting season.

## FEASIBILITY OF FASTING MIGRATION IN OSPREY OF THE INTERIOR AMERICAN WEST

CANDLER, G.L. AND P.L. KENNEDY. *Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523*

We reviewed current research on raptor migration and developed an energetics model to examine the potential importance of fasting on migration times of Osprey (*Pandion haliaetus*) migrating through the interior of North America. These piscavores fly inland over the semi-arid West and Mexico before arriving at their wintering area on the Pacific coast of southern Central America. The inter-west population also winters further north and may expend less energy during their migration than coastal Osprey, which must use powered flight to cross large water barriers. Therefore, fasting would seem to be more probable in this shorter distance, lower energy migration with limited prey availability. Our model predicts that a 1.68 kg Osprey would take 22 days, consuming 0.530 kg of fat (a fat density of 32% of lean body mass), to complete a fasting migration of 7800 km. Due to limits of daily intake, it was calculated to take 13 days of maximum energy intake to deposit this fat density. The predicted travel time for fasting migration was comparable to migration times estimated from lookout observations and banding data. If these Osprey did not fast during the entire migration, they would have to spend time foraging daily or break up their trip into several segments that are separated by stopovers to replenish their fat reserves, and we found that this would increase their migration time dramatically.

## OFFSPRING SEX RATIOS OF AMERICAN KESTRELS IN SOUTHWESTERN IDAHO

CARPENTER, G.P. *RRTAC, Department of Biology, Boise State University, 1910 University Drive, Boise, ID 83725*

A two-year study of American kestrel (*Falco sparverius*) offspring sex ratios was begun in 1992. Seventy-six nest boxes in southwestern Idaho were monitored closely to identify laying and hatching sequences. Diets of selected pairs were supplemented while control pairs were not to test the effect of resource availability on sex ratio. Nestlings were weighed and measured frequently to compare differential allocation of food to mass and feather development by male and female offspring and to compare production costs of each gender. The study's theoretical basis, design, and preliminary results will be discussed.

USING GEOGRAPHIC INFORMATION SYSTEMS TO ANALYZE BALD EAGLE HABITAT USE IN THE CHESAPEAKE BAY, USA

S.K. CHANDLER, J.D. FRASER AND D.A. BUEHLER. *Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.* J.K.D. SEEGAR. *U.S. Army Chemical, Research, Development and Engineering Center, Aberdeen Proving Ground, MD 21010*

We trapped bald eagles (*Haliaeetus leucocephalus*) using padded leghold traps and floating noosefish and by climbing to nests. Eagles were fitted with solar-powered radio transmitters, in a backpack configuration. The package was attached using teflon ribbon sewed near the sternum. Eagles were relocated ($N > 1000$) by using Cessna fixed-wing aircraft fitted with strut-mounted yagi antennas. We homed on the radio-signal to obtain a visual location and then plotted eagles' positions on 1:24 000 maps. UTM coordinates were digitized from the maps and stored in a file on our Micro-Vax III mini computer. We used ARC-INFO to overlay eagle locations on several different habitat data bases. We used ARC-INFO to calculate the amount of habitat available in various classes, which facilitated use vs. availability analyses. Telemetry used in conjunction with GIS databases has great potential for analyzing habitat use by raptors with very large home ranges.

THE CAPE MAY RAPTOR BANDING PROJECT: 25-YEAR SUMMARY

CLARK, W., C. SCHULTZ AND P. KERLINGER. *Cape May Bird Observatory, Box 3, Cape May Point, NJ 08212*

Since 1967, more than 81 000 migrating diurnal raptors have been captured and banded at Cape May Point, NJ, U.S.A. The research objective is to determine where these raptors are breeding and wintering, as well as their migration pathways. Data on measurements, age, sex, and condition have been gathered from the captured hawks. More than 1200 band recoveries have been reported, but only 147 previously banded raptors were captured and only 20 raptors were recaptured in subsequent years. A Common Kestrel (*Falco tinnunculus*) was captured in 1972 (second North American record). Ten Swainson's Hawks (*Buteo swainsoni*) have been captured from 1973 to present; one of these was recovered in Nova Scotia. Recovery data and most of the banding data are on computer data bases. Data are presented by species on the number banded and recovered and age and sex ratios. Published results are summarized. Captured raptors were made available to other raptor projects, including studies of the U.S. Fish and Wildlife Service, New Jersey Endangered Species and Non-game Program, New Jersey Audubon Society, University of Miami (Florida), University of Pennsylvania Veterinary School, Stockton State College, Tufts University, Utah State University, and Virginia Tech. Many raptor biologists (some from other countries) have received intensive training on capture techniques, age and sex determination, and behavior of raptors. Biologists from more than a dozen countries have observed the project operation. More than 35 000 people have attended demonstrations using banded raptors for public education, and heard our raptor conservation message. Funding is primarily from private sources, particularly from the WindSeine project of the CMBO. Most of the field work is conducted by highly qualified volunteers. Future research directions and publications are discussed.

RAPTOR EDUCATION—COMPLETING THE CIRCLE OF SPECIES SURVIVAL PLANS

CRAWFORD, JR., W.C. *World Bird Sanctuary, P.O. Box 270270, St. Louis, MO 63127*

It has been said that "All great environmental battles will be won or lost in this decade." As depressing as this sounds, there are still numerous positive aspects of conservation that are being conducted about which the public is unaware. Valuable field research is helping develop ecosystem management plans and species survival programs. Making the general public understand raptors and their place in our modern society has fallen on the shoulders of the raptor educators. Any comprehensive conservation programs for raptors must include field biologists working closely with educators. The World Bird Sanctuary (WBS) has developed an extensive education program that is designed to make the public more aware of what they must do to preserve raptors. Programs from preschool to senior citizens allow WBS to reach over 2 million people each year. Using data provided to us by field biologists, these programs are an effective tool in cooperative preservation programs for raptors. These programs, their design and complexity, will be discussed in detail.

MANAGEMENT OF A BALD EAGLE COMMUNAL ROOST IN MIXED-CONIFER FORESTS OF SOUTHERN OREGON

DELLASALA, D.A. *EBASCO Environmental, 10900 NE 8th St., Bellevue, WA 98004-4405.* R.G. ANTHONY. *U.S. Fish and Wildlife Service, Oregon Cooperative Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331.* T.A. SPIES. *USDA Forest Service, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, OR 97331.* K.A. ENGEL. *EBASCO Environmental, 10900 NE 8th St., Bellevue, WA 98004-4405*

Traditional management of bald eagle communal roosts has been confined primarily to seasonal restrictions on human activity and protection from habitat alterations. However, simply prohibiting direct disturbance of roosts may not preserve essential habitat characteristics over the long-term, especially in areas where natural disturbances (e.g., fire) have historically shaped stand composition and

structure. We provide a management plan for a bald eagle (*Haliaeetus leucocephalus*) roost at the Bear Valley National Wildlife Refuge (BVR) in southern Oregon. Roost habitat was studied on 3 spatial scales of increasing size, including roost trees, vegetation surrounding roost trees (i.e., roost sites), and 4 subsections of the main roosting area (i.e., subroosts). Primary roost tree species included Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and white fir (*Abies concolor*). Bald eagles used the largest (diameter at breast height), tallest, and oldest trees with open branching patterns. Differences in eagle use were attributed to growth rates and structural features of the 3 primary roost species. Douglas-fir was used at a younger age and was characterized by more open branching than other species. Ponderosa pine, an important species used by eagles in other areas in the region, did not receive high use at the BVR due to prior logging of the larger (>60 cm dbh) pines. When compared to unused sites, roost sites had 2–3 times as many large-diameter Douglas-fir, twice as many trees with open branching, 4 times as many snags, and greater tree height diversity. Subroost use by eagles was positively related to high densities of large Douglas-fir, low densities of late-seral white fir, and low stump densities. Mechanical thinning and prescribed fire were recommended to reduce white fir densities in portions of the roost where establishment of ponderosa pine and Douglas-fir were apparently inhibited by competition with late-seral white fir.

## EFFECTS OF FOOD ON BALD EAGLE DISTRIBUTION AND MOVEMENTS ON THE NORTHERN CHESAPEAKE BAY

DELONG, JR., D., D.A. BUEHLER, T.A. MERSMANN AND J.D. FRASER. *Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.* J.K.D. SEEGAR. *Chemical Research, Development and Engineering Center, Aberdeen Proving Ground, MD 21010*

We studied the effects of food on bald eagle distribution on the northern Chesapeake Bay during 1986 through 1989. We monitored the distribution of unmarked bald eagles through monthly aerial shoreline surveys, and the movements of 39 radio-tagged bald eagles through twice-weekly telemetry flights. We also monitored the distribution and abundance of fish and waterfowl which were the primary prey eaten by eagles during our study. Preliminary results indicated that annual cycles in bald eagle distribution were highly correlated with annual cycles in fish and waterfowl distribution on the study area. We subsequently initiated an experimental feeding program to test for cause/effect in this correlation. Fish were supplied daily at 2 sites on Aberdeen Proving Ground, Maryland, beginning in late September 1988. This was to simulate a non-declining food source at the time of year when fish abundance declines on the northern Bay, and bald eagles leave the study area for southern portions of the bay. The feeding program did not seem to curtail the movement of bald eagles to the southern portion of the bay, although it did have a significant impact on the distribution of eagles that remained on the study area. A greater understanding of the factors affecting bald eagle distribution, including the relative importance of each, will allow managers to more effectively manage bald eagle populations.

## BREEDING BIOLOGY OF THE WHITE HAWK IN GUATEMALA

DRAHEIM, G. *RRTAC, Biology Department, Boise State University, Boise, ID 83725*

Although thirty-nine percent of the world's falconiform species are found in the rainforest, very little is known about these raptors. The White Hawk (*Leucopternis albicollis ghiesbreghti*), a medium-sized *Buteo*-like raptor, is found from southern Mexico through Belize and Guatemala. I studied this neotropical species during the 1991 and 1992 breeding seasons in Tikal National Park, Guatemala, in order to describe their general breeding biology The White Hawks begin courtship displays and nest building in February, and by mid- to late-March egg laying and incubation begin. Their stick nests were found in five different species of trees. The mean dbh of six nest trees was 70.1 cm and the nest height averaged 25.4 m above the ground. Nests averaged 43.8 × 67.3 cm across and 28.4 cm tall. Each nest contained one egg ($N$ = 4) Of one hundred sixty-four prey items observed, 56% were reptiles, 20% unidentified, 14% mammals, 6% birds, 2% insects, and 2% amphibians. Prey items varied from small lizards (*Anolis* sp.) to medium-sized squirrels (*Sciurus deppei*). Prey items were delivered at a rate of 1 to 4 (mean = 1.9) times per day. The incubation period was 34–36 days ($N$ = 2) and one chick fledged 88 days after hatching. Home ranges for one breeding male and one sub-adult were 208 ha and 46 ha, respectively. Although yellow is the reported eye color for this subspecies, all 20 birds located in northern Guatemala had brown eyes.

## GREAT HORNED OWLS DO NOT EGEST PELLETS PREMATURELY WHEN PRESENTED WITH A NEW MEAL

DUKE, G.E., S. JACKSON AND O.A. EVANSON. *The Raptor Center, University of Minnesota, St. Paul, MN 55108*

Whether owls are able to cephalically, or even voluntarily, control pellet egestion in response to external stimuli has long been a question. It has recently been shown that meal-to-pellet interval (MPI) in one owl can be influenced by the visual presence of other owls, so some cephalic control is possible. Our objective was, therefore, to determine if Great Horned Owls could egest a pellet when presented with a new meal near the time when they would be expected to egest from a previous meal. Four owls, held individually in environmentally controlled rooms, were fed 40–60 g/kg daily at 0800 H for about 4 weeks. Mean and

standard deviation (SD) for MPI were calculated for each owl. During the next 8 weeks, each owl was fed one day per week (randomly selected) at a time equal to one SD prior to the mean MPI (i.e., prior to expected egestion time). We expected that when presented with a meal (mice) at this time, owls would a) not eat immediately, but initiate egestion and eat within 15–30 minutes, b) eat the new meal on top of the undigested remains of the previous meal still in the stomach, or c) not eat within 30 minutes and thus miss the opportunity to ingest a new meal. With one exception when we observed a, we otherwise always observed b, i.e., they ate on top of a previous meal. Pellets from these "double" meals were less than twice as heavy as pellets from a single meal, so digestion was apparently slightly better after two meals. Thus, not only do owls not miss the chance to eat a second meal because a first meal is not yet completely digested, their digestion may even be slightly more efficient when the second meal is eaten.

## MOVEMENTS AND HABITAT USE BY COMMON RAVENS FROM ROOST SITES IN SOUTHWESTERN IDAHO

ENGEL, K.A. *EBASCO Environmental, 10900 NE 8th Street, Bellevue, WA 98004.* L.S. YOUNG. *Washington Department of Natural Resources, Forest Land Management Division, P.O. Box 47016, Olympia, WA 98504-7016*

Increasing conflicts between ravens and human interests in the western United States necessitate a better understanding of raven ecology, especially with respect to human land alterations. We observed daily movements and habitat use of 31 radio-marked common ravens (*Corvus corax*) from four communal roosts in the Snake River Birds of Prey Area in southwestern Idaho from April 1985 through February 1987, and recorded their activities relative to various human-related food sources (e.g., croplands, cattle feedlots, and refuse landfills). Daily maximum distances traveled from roost sites were similar ($P = 0.63$) among seasons, but not ($P < 0.01$) among roosts. Ravens from roosts located within 1 km of a concentrated human-related food source traveled shorter (all $P < 0.03$) distances from roosts than ravens that were not. Ravens spent an average of 54% of the day in agricultural land, followed by shrub (23%), grass (13%), and riparian habitats (6%). Raven use of various habitats was similar (all $P > 0.27$) among seasons. Likewise, raven use of agricultural, riparian, and shrub habitats was similar ($P > 0.06$) among roosts, although use of grass habitats was lower ($P < 0.01$) at one roost. Raven roost locations, daily movements, and habitat use were associated with human-related food sources. Raven populations may thus be managed through manipulation of raven food supplies, particularly those related to human activities.

## OCCURRENCE AND NESTING HABITAT OF NORTHERN SPOTTED OWLS IN MANAGED YOUNG-GROWTH FORESTS IN NORTHWESTERN CALIFORNIA

FOLLIARD, L.B. *College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83843.* L.V. DILLER. *Simpson Timber Company, P.O. Box 1169, Arcata, CA 95521.* K.P. REESE. *College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83843*

From 1989 through 1992, approximately 120 000 ha of managed, young-growth forests were surveyed for northern spotted owls (*Strix occidentalis caurina*) in coastal northern California. To date, 169 owl sites have been identified and over 500 birds banded (including 197 juveniles). The relative density of owl sites was greatly influenced by the amount of acreage of forest >45 years old. The region with the highest density (about 0.46 owl sites/$km^2$) had 37% of the landscape in this older age class. Habitat analysis of 60 nesting pairs revealed that owls nested in stands that varied from pure conifer to those dominated by hardwoods, with no apparent selection for a particular cover type. The median nest stand age was 59 years, with 83% of pairs nesting in stands 35–80 years old. On average, conifer nest stands were dominated by trees 53–90 cm dbh in size. Although the density was low, there was a higher density of large (>90 cm dbh) conifers ($P = 0.010$) in nest stands in comparison with randomly selected stands. In general, hardwood nest stands had smaller trees than conifer stands. In comparison with old-growth forest structure, the most distinctive difference was the low density of trees >90 cm dbh in these managed stands. Favorable conditions in the redwood (*Sequoia sempervirens*)/Douglas-fir (*Pseudotsuga menziesii*) coastal region such as rapid tree growth rates and an abundant prey base, make these second-growth forests suitable spotted owl habitat at an early age. Development of spotted owl habitat in this region can occur at an accelerated rate following timber harvest in comparison with other regions of the species' range.

## ANALYSIS OF PESTICIDE EXPOSURE RISK TO RED-TAILED HAWKS WINTERING IN ALMOND ORCHARDS IN CALIFORNIA

FRY, D.M., B.W. Wilson, N.D. Ottum, J.T. Yamamoto and R.W. Stein. *Department of Avian Sciences, University of California, Davis, CA 95616.* J.N. SEIBER, M.M. MCCHESNEY AND E. RICHARDSON. *Department of Environmental Toxicology, University of California, Davis, CA 95616*

Red-tailed Hawks (*Buteo jamaicensis*) become exposed to organophosphate (OP) pesticides while wintering in the central valley of California. Previous work on birds trapped by M. Hooper, P. Dietrich, and E. Littrell showed exposure associated with OP dormant spraying in almond orchards. This study extends that work by examining winter home ranges of hawks, pesticide use within home ranges, and documentation of exposure through analysis of foot washes, feather samples, and feces. The exposure risk from

the four principal OP compounds used on almonds was estimated by correlating: 1) residues on hawks with spray application timing relative to capture of birds and 2) correlations with serum cholinesterase depression. The probable routes of exposure to the birds include dermal absorption through feet and ingestion of residues from prey and during preening. This work was supported by the Almond Board of California.

### Telemetry Via Satellites for Raptor Studies

M.R. Fuller, D.H. Ellis and S.S. Klugman. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708.* W.S. Seegar. *Chemical Research, Development and Engineering Center, Aberdeen, MD 21010*

Monitoring animal movements by satellite was first accomplished in 1970 with an elk in Wyoming. The large size of early transmitter packages restricted their use to very large animals. Miniaturization of electronic components in the 1980s allowed application of satellite telemetry to large birds. Satellite transmitters have been tested with mixed results on geese, swans, petrels, bustards, eagles, and falcons. Dramatic weight reduction in the 1980s was quickly followed by tests of a variety of transmitter shapes on captive birds. Research on attachment methods helped in selecting those methods least likely to elicit adverse behavior. Wind tunnel experiments were conducted to produce more aerodynamically efficient PTT designs. Recently, the utility of satellite tracking has been demonstrated in studies of wandering albatrosses in the Indian Ocean, migrating Bewick's swans, bald eagles, and golden eagles. Two other studies demonstrated the feasibility of tracking cranes by satellite. The types of information from these techniques will be presented and cross-referenced to a poster display and demonstration.

### Habitat Selection by Mexican Spotted Owls in Northern Arizona

Ganey, J.L. *USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Flagstaff, AZ 86001.* R.P. Balda. *Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ 86001*

Although the Spotted Owl (*Strix occidentalis*) has been the object of considerable attention in the Pacific Northwest, little is known about the habitat requirements of the Mexican Spotted Owl (*S. o. lucida*). We compared use of broad habitat types to availability of those types within the home ranges of eight radio-tagged Mexican Spotted Owls in northern Arizona. When all habitat types were considered, no owls used these types in proportion to availability. Use patterns differed among individuals and by activity type. All owls roosted primarily in virgin mixed-conifer forests. Owls generally foraged more than expected in virgin mixed-conifer and ponderosa pine (*Pinus ponderosa*) forests and less than expected in managed forests. Mature forests appear to be important to Spotted Owls in this region and different forest types may be used for different activities. Consequently, managers should retain virgin stands of both mixed-conifer and ponderosa pine forest where these owls occur, to provide both roosting and foraging habitat.

### Observations and Food Habits of Nesting Great Black-Hawks in Tikal National Park, Guatemala

Gerhardt, R.P. *The Peregrine Fund, Inc., 5666 W Flying Hawk Lane, Boise, ID 83709 (EEC Biology, University of Nevada, 1000 Valley Road, Reno, NV 89512-0013).* P.M. Harris. *The Peregrine Fund, Inc., 5666 W Flying Hawk Lane, Boise, ID 83709.* M.A. Vasquez Marroquin. *El Parque Nacional Tikal, El Petén, Guatemala*

Two active nests of the Great Black-Hawk (*Buteogallus urubitinga ridgwayi* Gurney) were located during the dry season in Tikal National Park, Guatemala. Nests were 20.5 m and 22 m high in mahogany (*Swietenia macrophylla*) and pucte (*Bucida bucerus*) trees, respectively. Each nest contained a single young. Direct nest observations yielded 106 prey items delivered to young; of these, lizards comprised 31%, snakes 28%, birds 13%, anurans and bats 8% each, rodents 6%, and an opossum 1%. Niche breadth (1/D) was 4.51. In terms of biomass, snakes represented 46% of the prey. Incubation time was approximately 40 days. Fledging occurred 65–70 days after hatching in the one successful nest.

### The Food Habits, Home Range and Breeding of Two Sympatric *Ciccaba* Owls

Gerhardt, R.P. *The Peregrine Fund, Inc., 5666 W Flying Hawk Lane, Boise, ID 83709 (EEC Biology, University of Nevada, 1000 Valley Road, Reno, NV 89512-0013).* D.M. Gerhardt. *The Peregrine Fund, Inc., 5666 W. Flying Hawk Lane, Boise, ID 83709.* N.B. Gonzalez. *El Parque Nacional Tikal, El Petén, Guatemala.* C.J. Flatten. *The Peregrine Fund, Inc., 5666 W. Flying Hawk Lane, Boise, ID 83709*

Thirteen Mottled Owl (*Ciccaba virgata*) nests were studied in Tikal National Park, Petén, Guatemala. Mean clutch size was 2.15. Nine of these nests fledged a total of 16 young and young left the nest at between 27 and 33 days of age. Mean home range size was 20.8 ha (85% harmonic mean) for six radio-tagged breeding males and the density of this population was 7.5 breeding adults per km$^2$. Mottled Owls were found to be highly territorial, sedentary, and monogamous. Four nests of the Black-and-white Owl (*C. nigrolineata*) are also described. All were in epiphytes in large, live trees. Mean nest height was 20.5 m. Each nest contained one egg. The home range size of a single radio-tagged male was 437.3 ha (85% harmonic mean) One pair studied during three consecutive years was found to be monogamous and completely sedentary. Both species

captured large insects, including beetles (primarily scarabaeid, curculionid and cerambycid), grasshoppers (Orthopetra; Acrididae), and cockroaches (Orthoptera; Blattidae). There was little overlap in the vertebrate component of the diets of the two species: Black-and-white Owls fed on bats (especially *Artibeus jamaicensis*), while Mottled Owls ate small rodents (including *Oryzomys fulvescens* and *Sigmodon hispidus*). Quantitative analysis of food habits was based on frequency of occurrence of prey taxa in pellets. One hundred percent of Black-and-white Owl pellets contained insect exoskeletal material; 73% contained bat fur and/or bones. Ninety-eight percent of Mottled Owl pellets contained insect matter, while 56% contained vertebrate remains.

## BREEDING AND WINTERING RANGES OF SHARP-SHINNED HAWKS (*ACCIPITER STRIATUS*) MIGRATING THROUGH THE CENTRAL APPALACHIANS OF NORTHEASTERN UNITED STATES: CONSERVATION IMPLICATIONS

GOODRICH, L.G. AND S. STRUVE. *Hawk Mountain Sanctuary Association, Route 2, Box 191, Kempton, PA 19529*

Hawk watches at coastal locations in eastern North America have reported precipitous declines in counts of Sharp-shinned Hawks (*Accipiter striatus*) in recent years. However, nearby Appalachian sites have only recently noted a decline. To interpret hawk count trend comparisons, we first need to determine the origin of the birds being sampled at each site. To ascertain if the birds migrating through the Appalachians originate from the same populations as those sighted along the east coast, we examined band recovery data on all Sharp-shinned Hawks banded prior to 1990 in the eastern Appalachians ($N = 212$) and compared it to that reported for Cape May, New Jersey. Band recovery data suggest that the breeding and wintering ranges of Sharped-shinned Hawks that migrate through the Appalachian flyway overlap extensively with those reported for birds banded on the coastal flyway. In contrast to central and western populations, eastern Sharp-shinned Hawks were found to winter predominately within the United States. We found no difference in wintering range among age and sex classes of Appalachian birds. Because immature birds comprise most of the coastal observations, and band recovery data suggest coastal birds and Appalachian birds originate from similar populations, we propose that recent declines reflect on inhibition of reproduction over a wide region of the northeast rather than a localized decline.

## MORPHOLOGICAL DIFFERENCES OF FERRUGINOUS HAWKS (*BUTEO REGALIS*) EAST AND WEST OF THE ROCKY MOUNTAINS

GOSSETT, D.N. AND M.J. BECHARD. *RRTAC, Department of Biology, Boise State University, 1910 University Drive, Boise, ID 83725*

In 1991, the U.S. Fish and Wildlife Service (USFWS) received a petition to list the Ferruginous Hawk (*Buteo regalis*) as threatened or endangered under the Endangered Species Act. Status reviews have found that the overall population has increased in recent years. However, most of this increase has occurred in populations east of the Rocky Mountains, and some western populations may still be suffering declines. To determine if morphological and genetic differences exist between what have been speculated to be separate subpopulations, 70 adult Ferruginous Hawks were trapped at nesting areas east and west of the Rocky Mountains in 1991 and 1992. Initial analysis using multivariate analysis of variance and Duncan's multiple-range test indicates a significant morphological difference between areas (females: $P < 0.0001$, males: $P < 0.0035$, with a Bonferroni corrected significance level). Eastern populations were heavier than western populations (female mass means = 1871 g vs. 1680 g, male mass means = 1239 g vs. 1098 g, respectively). Other character means that were significantly different included third toe length, bill chord, horizontal bill, and gape width. Additional results will be discussed.

## SELECTION OF PREY AND FORAGING METHODS IN BREEDING AMERICAN KESTRELS

GUERRERO-GONZALEZ, F.M. *N6789 Third Avenue, Plainfield, WI 54966*

The foraging theory predicts that the use of food and choice of foraging method by an animal are influenced by the pattern of abundance, nutritional value, and cost of capture of prey potentially available. I studied the American Kestrel's use of prey by determining presence or absence of prey items in a total of 685 pellets collected weekly from 26 breeding birds in 1991. I found four principal prey groups: insects, mammals, birds, and snakes. When insects were scarce, a higher proportion of mammals appeared in the pellets and vice versa. The presence of birds in the diet correlated with the abundance of fledglings. Finally, snakes were represented only from mid-May until early August. Results of my first year's study gave insight on the use of prey. However, some questions arose, such as: did kestrels use the most available prey?, was the choice of prey influenced by its abundance?, and finally, what foraging methods were used? I recorded hunting method, hunting success, and prey item from 22 breeding birds daily in the mornings at intervals of 30 seconds in sessions of 5–300 minutes in 1992. I also sampled three major prey populations: beetles, grasshoppers, and mice, to obtain their relative abundance throughout the seasons. The data suggest that kestrels made optimal selection of prey and foraging method. They selected the most rewarding item dependent on prey density, but whenever two prey types were abundant they switched to the one of better quality. Kestrels used perch hunting when trying for insects, and hovering and flight hunting while attempting to catch

mammals and birds. Nevertheless, the use of a method requiring less or more energy was determined by the nutritional value and/or abundance of the prey.

### A Comparison of Nest Sites of the Northern Goshawk in Arizona and California

HALL, P.A. *Northern Arizona University, School of Forestry, Box 4098, Flagstaff, Arizona 86011*

The northern goshawk is considered an indicator species for old-growth forests in the western United States by a number of state and federal agencies. Studies of the species have evoked a growing concern about the effects of forest management practices on the viability of western population, as evidenced by the recent petition to the U.S. Fish and Wildlife Service to list the species as threatened. Information on goshawk habitat requirements in Arizona is scarce and there is justifiable reticence to apply results from other vegetation zones or physiographic provinces. The object of this analysis is to identify differences and commonalities in the structural and physiognomic characteristics of nest sites in two study areas in different regions; northern Arizona ponderosa pine and northwestern California Douglas-fir. A multivariate analysis-of-variance revealed an overall significant difference between nest sites, nest trees, and nests in the two areas. These differences are based on characteristics attributable to species growth patterns and climate, such as: basal area, stem density, canopy closure, and tree height in the nest sites; nest tree height and diameter; and the position of the nest within the nest tree and nest site canopies. Multistoried canopies prevail in California while single-storied canopy structure is predominant in Arizona. However, all nest sites are park-like due to the absence of a shrubby understory. Nest sites and nest trees are comprised of the locally dominant species. The distributions of tree size classes are similar. Nest tree diameters generally fall in the two largest size classes and classify as old growth on average. There are problems extrapolating results from one study area to another. This comparison begins to identify generalizable characteristics which can be applied to goshawk management on a broader scale.

### Hybridization Between Barred and Spotted Owls

HAMER, T.E. *Washington Department of Wildlife, 600 Capitol Way North, Olympia, WA 98504*. E.D. FORSMAN. *USDA Forest Service, Forestry Sciences Laboratory, Corvallis, OR 97331*. A.D. FUCHS AND M.L. WATERS. *Puget Power and Light Company, Bellevue, WA 98009*

We present the first records of interspecific hybridization between the Northern Barred Owl (*Strix varia varia*) and Northern Spotted Owls (*S. occidentalis caurina*). Two hybrid owls in Washington and two in Oregon were confirmed during 1989–92. One of the hybrids paired with a Barred Owl and produced young in 1990 and 1991. In addition, we confirmed the pairing of a female Barred Owl to a one-year-old male Spotted Owl, which produced at least one young in 1992. Hybrids were identified by their unique plumage, unusual vocalizations, and morphological measurements. All three adult hybrids had similar plumage characteristics and vocalizations. Body measurements of hybrids were intermediate between Barred and Spotted Owls, and sonograms of vocalizations displayed attributes of both species. Although genetic comparisons have not yet been conducted, we believe the three adult specimens we observed were all F1 crosses between Barred and Spotted Owls. Hybridization between these species and successful back-crossing by hybrids indicates that the designation of the Barred and Spotted Owl as a superspecies is appropriate.

### A Disastrous Breeding Season for American Kestrels—1992

HAMERSTROM, F.N. *6789 3rd Ave., Plainfield, WI 54966*

We have monitored 50 American Kestrel (*Falco sparverius*) nest boxes on an approximately 50 000 acre (20 234 ha) study area in central Wisconsin for 25 years (1968–92). The number of young fledged per year had risen since 1968 and then it declined since 1982. The mean number of young fledged 1968–92 was 52. The most strikingly aberrant year was this past season. Only 11 young fledged.

### Peregrine Recovery in the Rocky Mountains and Pacific Northwest

HEINRICH, W.R. *The World Center for Birds of Prey, 5666 West Flying Hawk Lane, Boise, ID 83709*

By the late 1970s no Peregrines were known to be breeding in Montana, Idaho, or Wyoming, and only small remnant populations were known to exist in Colorado, New Mexicò, northern Utah, Washington, and Oregon. In 1975, The Peregrine Fund established a breeding facility in Ft. Collins, Colorado, with specific objectives to begin raising and releasing Peregrines in the Rocky Mountains. Since 1978, over 1650 Peregrines have been released in the Rocky Mountains and Pacific Northwest. The program has successfully met recovery objectives in Colorado and Utah. Additionally, since 1980 a total of 830 Peregrines have been released in Montana, Idaho, and Wyoming. In 1992, 40 known pairs produced over 73 young in those states (1.8 young per pair). Over 209 Peregrines have been released in Oregon and Washington since 1980 when only four pairs were known. Today, over 45 pairs are present. The Peregrine Fund, in cooperation with agencies in Montana, Wyoming, Idaho, Washington, and Oregon, plans to continue releasing about 130 Peregrines a year

through 1995. After that time we believe state and federal recovery objectives will have been achieved.

## RECENT TRENDS IN COUNTS OF MIGRATING HAWKS FROM WESTERN NORTH AMERICA

HOFFMAN, S.W., J.C. BEDNARZ AND W.R. DERAGON. *HawkWatch International, P.O. Box 5706, Albuquerque, NM 87176-5706*

Diurnal raptors were tallied during migration periods at the Wellsville (Utah), Goshute (Nevada), Manzano (New Mexico) and Sandia (New Mexico) mountains for 6–8 years/site between 1977 and 1991. Of several variables analyzed, only the number of observers present ($P < 0.05$) significantly influenced the detection rates of raptors. We adjusted the data to standardize for the duration of sampling period and the number of observers, and applied trend analyses. Trends of 15 raptor species were examined and counts of 11 species were either slightly increasing or showed no change in numbers. Turkey Vultures and Ospreys were significantly increasing. Conversely, counts of migrant Northern Goshawks and Golden Eagles decreased at mean rate of 4.4% and 6.1% per year, respectively. Interpretation of these declines is somewhat enigmatic; however, these patterns are consistent with limited evidence that widespread alteration of forest, and possible rangeland habitats, is occurring in western North America.

## NORTH AMERICAN BANDING OF GREAT HORNED OWLS

HOUSTON, C.S. *863 University Drive, Saskatoon, SK, Canada S7N 0J8*

The Great Horned Owl, widely distributed across North America, has been banded in every state except Hawaii and in all ten Canadian provinces, with 24 787 banded between 1955 and 1989. Of these, 19 073 were normal wild birds (status 3000), including 17 491 nestlings or flightless young (locals). Numbers banded annually have tended to increase from a low of 131 in 1956 to a high of 1335 in 1986. Over one thousand were also banded annually in 1972, 1976, 1981, 1983, 1987, and 1988. Of 1032 Great Horned Owl banders, 37 have banded 100 or more, at least two of them primarily dealing with rehabilitated owls. States and provinces with the most banded are Saskatchewan (6184), Alberta (1862), Ohio (1768), Wisconsin (1335), and California (1253). To date, there have been 2308 recoveries, a rate of 9.3%, unusually high for a non-game species. Another 296 recoveries are available from banding done between 1920 and 1954, much of it in Ohio, Michigan, and New York. Although a year-round resident previously considered to be non-migratory, individual owls from Alberta, Saskatchewan, Manitoba and North Dakota have travelled great distances: an Alberta owl was caught in a building in Illinois, 2057 km distant, seven months after it was banded as a nestling.

## FORAGING RANGE OF RIVER NESTING BALD EAGLES

HUNT, G. *BioSystems Analysis, Inc., 303 Potrero, 29-203, Santa Cruz, CA 95060*

In a three-year study of bald eagles in Arizona, we tracked the daily movements of nine radio-tagged adults during the breeding season while simultaneously observing prey deliveries to the nest. The eagles took live and carrion fish in both riverine and lacustrine habitats. We mapped foraging range per kilometer according to the distribution of 1) perching events, 2) direct observations of foraging, and 3) telemetric data on the whereabouts of eagles in the minutes prior to nest delivery. To account for the large number of perching events near the nest that were unrelated to foraging, we weighted the range data according to the proportion of forages occurring in the nest vicinity. Foraging ranges of eagles were a measure of habitat quality and distribution: eagles were attracted to specific habitats where prey were vulnerable, and in most cases these habitats were not homogeneously distributed within the home range. Other factors affecting foraging range included distribution of strategic perches and isolation from disturbance. This study was funded by the U.S. Bureau of Reclamation.

## HABITAT USE AND RELATIVE ABUNDANCE OF THE BAT FALCON IN THE SELVA LACANDONA REGION OF CHIAPAS, MEXICO

IÑIGO-ELIAS, E.E. *Department of Wildlife and Range Sciences, Program for Studies in Tropical Conservation, University of Florida, Gainesville, FL 32611-0304*

The Bat Falcon (*Falco rufigularis*) is among the most common neotropical raptors. Nevertheless, the biology and ecology of this species are poorly documented. The objectives of this study were 1) to evaluate the habitat use by this species along the Lancantún River in the southern portion of the Selva Lacandona and 2) to document seasonal, monthly, diurnal and spatial distributions along the Lacantún drainage. In order to estimate the habitat use and relative abundance, Bat Falcons were surveyed from September 1989 to August 1990 along 24 1-km walking transects (oriented perpendicularly to the river) and 11 15-km river transects along the Lacantún River. The data revealed that the mean relative abundance of the species was greatest between 0 and 100 m from the edge of the river. Bat Falcons tended to use the riparian evergreen tropical forest more often than any other natural or disturbed vegetation types. This species was more abundant during the rainy season. They were rarely detected during the breeding season, which occurs during the dry period of the year. Daily activity was highest during the early and late hours of the day. Recommendations for protecting riparian tropical forests are suggested based on the habitat used by this species. These survey techniques can be useful

for monitoring other Bat Falcon populations in other neotropical forests.

A REVIEW OF THE BALD EAGLE TRANSLOCATION PROJECT IN ALASKA

JACOBSON, M.J. *U.S. Fish and Wildlife Service, P.O. Box 021287, Juneau, AK 99802-1287*

Since 1981, over 350 nestling bald eagles (52% of production) have been removed from a study area within old growth forest of southeast Alaska for reintroduction to other states. Helicopter surveys have been used to determine nest occupancy and success in the removal and control areas. No detrimental effect on productivity within the removal area has been detected. Reintroduction projects from states receiving Alaskan bald eagles are briefly discussed.

FIELD EXPERIMENTS IN PREY SELECTION BY RESIDENT BALD EAGLES IN THE BREEDING AND NONBREEDING SEASON

JENKINS, J.M. *Technical and Ecological Services, Pacific Gas and Electric Co., 3400 Crow Canyon Road, San Ramon, CA 94583.* R.E. JACKMAN. *BioSystems Analysis, Inc., P.O. Box 776, Fall River Mills, CA 96028*

Implicit in the assumptions of modern foraging theory is that animals are capable of exercising choice in their foraging decisions. However, few empirical studies demonstrating such choice have been conducted. We devised a simple field experiment offering a choice of two prey items of unequal sizes to foraging bald eagles in the breeding and nonbreeding season. The objective of the field experiment was to determine if eagles nonrandomly selected one prey item over another, and if this choice varied between breeding and nonbreeding season. A total of 67 trials was conducted on four nesting pairs of eagles, 32 trials in the breeding season and 35 in the nonbreeding season. At each of the four territories, eagles selected the large fish during the breeding season more frequently than expected on the basis of chance. In the nonbreeding season, eagles took the large fish in about equal numbers as the small fish. However, eagles failed to take either fish 37.1% of the time during the nonbreeding season. This compares to only one instance of no response (3.1%) for breeding season trials. Mean response time was generally shorter in the breeding season than the nonbreeding season and eagles responded more quickly when they took the large fish irrespective of season. The latter result suggests that hunger level may have affected the eagle's decision to take the large fish. We conclude that eagles discriminate between large and small prey items and may alter their prey selection based upon hunger levels and increased energetic requirements of the breeding season. These results suggest additional reasons why food habits of bald eagles vary between the breeding and nonbreeding season.

HABITAT USED BY BALD EAGLES WINTERING ALONG THE SOUTH FORK BOISE RIVER, IDAHO

KALTENECKER, G. AND M.J. BECHARD. *RRTAC, Department of Biology, Boise State University, Boise, ID 83705*

Foraging and perching habitats used by bald eagles (*Haliaeetus leucocephalus*) wintering along the South Fork Boise River in southwestern Idaho were studied during the winters of 1990–91 and 1991–92. Aerial surveys showed that eagles concentrated mostly along a 25 km stretch of river located in mature cottonwood trees (*Populus trichorcarpa*) and preyed upon largescale suckers (*Catostomus macrochielus*), mountain whitefish (*Prosopium williamsoni*), and rainbow trout (*Oncorhynchus mykiss*). River and surrounding habitat characteristics were measured at each prey capture and perching site, as well as at an equal sample of random sites. River habitat type, depth, velocity, number of surrounding perches, and proximity to the nearest river habitat change were among variables measured at each site. Eagles selected deeper and slower habitats (pools) for foraging more than expected. Abundance of fish, both alive and dead, was found to be higher at pools than other habitat types. Eagles also used habitats containing more surrounding perches than were available at random. In addition to pools, transitional river habitat types (23% of use sites) were used more often than available (14% of random sites measured). Findings may aid managers in identification or protection of key foraging habitats within existing wintering areas. Results indicated the importance of pools, transitional zones, and riparian habitats containing stands of mature cottonwood trees. Recommendations for flow regimes and land-use practices along dammed, riverine habitats used by bald eagles will be made to ensure healthy riparian vegetation and the availability of mature cottonwoods.

RESPONSIVENESS OF NESTING NORTHERN GOSHAWKS TO TAPED BROADCASTS OF THREE CONSPECIFIC CALLS

KENNEDY, P.L. *Department of Fishery and Wildlife Biology, Colorado State University, Ft. Collins, CO 80523.* D.W. STAHLECKER. *Eagle Environmental, Inc., Route 7, Box 126-Z, Santa Fe, NM 87505*

We wanted to determine if broadcasting conspecific vocalizations of northern goshawks (*Accipiter gentilis*) increased their detectability during the nesting seasons, because locating nest sites of this forest-dwelling raptor is difficult and time-consuming. Consequently, we recorded responses of northern goshawks to an observer walking transects and either broadcasting alarm, wail and juvenile begging calls of goshawks or not broadcasting during 1990 in northcentral New Mexico and northcentral Arizona We sampled 215 transects at 27 northern goshawk nests during sampling periods associated with courtship, nestling, and fledgling-dependency during the nesting season.

Northern goshawk responses to taped conspecific calls were significantly ($P = 0.02$) higher than their responses to an observer without a tape. Detection rates were highest on transects with broadcasts during the nestling (73.1%) and fledgling-dependency periods (75.0%). During all sampling periods, the probability of detecting a northern goshawk was highest for observers broadcasting a conspecific vocalization within 150–200 m of the nest. During the nestling period, the alarm call elicited the highest detection rate while the wail and begging calls resulted in the highest detection rate during the fledgling-dependency period. Vocal mimics by jays (potential false positives) occurred on 16.7% of the transects. The lowest mimicry rates occurred during the nestling period. We recommend that northern goshawks be surveyed with broadcast conspecific vocalizations during brood rearing at stations that are 300 m apart on transects that are separated by 260 m, and that stations on adjacent transects be offset by 130 m.

### LANDSCAPE ANALYSIS OF NORTHERN GOSHAWK HABITAT IN TWO FOREST REGIONS OF PENNSYLVANIA

KIMMEL, J.T. *Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475.* R.H. YAHNER. *School of Forest Resources, The Pennsylvania State University, University Park, PA 16802*

We studied nesting habitat of Northern Goshawks (*Accipiter gentilis*) in Pennsylvania at the landscape level from 1988–92. Our objectives were to 1) contrast habitat "use" (i.e., habitat surrounding goshawk nests) with habitat "availability" (habitat associated with random points), 2) identify differences in habitat use between the Northern Hardwoods (NH) and the Appalachian Oak (AO) forest regions of the state, and 3) evaluate the relative importance of landscape features at varying levels of spatial scale. These levels were represented by six sizes of circular plots centered on nests and random points ranging from 10 ha (i.e., the "nest site" area) to 1960 ha (approximate "home range" area). Color infrared aerial photographs (1:58 000) and 7.5-min topographic maps were used to quantify landscape habitat variables. Univariate analyses indicated that goshawks selected nest sites ($P < 0.05$) on more gentle slopes and further from non-forest edges and medium-heavy duty roads on both forest regions ($N = 46$ and 29 nests and 37 and 38 random points in the NH and AO regions, respectively). At the "home range" level, nests were associated with more extensive forests, greater amounts of evergreen/mixed stands, and less residential land use areas. A slight preference for northerly aspects was observed for nests occurring on steeper slopes in the more southerly AO region. Differences in habitat use between forest regions (independent of habitat availability) indicated that goshawks in the NH region nested at higher topographic positions and in areas containing less conifers proximal to the nest tree. Comparison of results from logistic regression analysis of the different-sized plots suggested that nest site habitat may be more of a limiting factor in the AO region, but that potentially higher quality foraging habitat (represented by extensive forests with mixed/evergreen stands) may be important for goshawks throughout the state. Management recommendations regarding extent of forests and evergreen/mixed stands were derived from logistic regression models and will be presented.

### DIFFERENTIAL SPACE USE BY MALE AND FEMALE PRAIRIE FALCONS (*FALCO MEXICANUS*): CONSEQUENCES FOR SAMPLING REQUIREMENTS TO ESTIMATE HOME RANGES

KIMSEY, B.A. AND J.M. MARZLUFF. *Greenfalk Consultants, 8210 Gantz Avenue, Boise, ID 83709*

Determining the minimum sample of location estimates (fixes) adequate to describe an animal's home range is important in developing sampling protocols. In the Snake River Birds of Prey Area, male and female adult prairie falcons have different spatial use patterns and we report that this influences the minimum number of fixes necessary to describe male and female ranges. We sampled 60 radio-tagged adult falcons throughout the 1991 and 1992 breeding seasons and determined that females remained close to the aerie until late brood-rearing and then traveled throughout a wider foraging range, whereas males traveled throughout their entire foraging range during all phases of the breeding cycle. Maximum home range size of females was, therefore, primarily determined by fixes taken during late brood rearing and post-fledgling stages, whereas male maximum home range size was determined earlier in the breeding cycle. Because of this, it is necessary to obtain most of the fixes from late in the breeding cycle in order to adequately sample a female's home range. Males can be sampled throughout the breeding cycle. The total number of fixes should not be the only criterion used to select adequately sampled home ranges; temporal distribution of fixes is also important. In particular, some females with large numbers of fixes originating early in the breeding cycle had poorly sampled home ranges, while others with fewer total fixes but with a majority late in the breeding cycle had adequately sampled home ranges. Many raptors may show similar differences in male and female spatial use patterns and these differences should be taken into account in deciding how to sample an individual's home range.

### USE OF SATELLITE TELEMETRY FOR STUDY OF A GYRFALCON IN GREENLAND

KLUGMAN, S.S. AND M.R. FULLER. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708.* P.W. HOWEY. *Microwave Telemetry, Inc., Suite 120, 8945 Guilford Road, Columbia, MD 21046.* M.A. YATES. *P.O. Box 3480, Carson City, NV 89702.* J.J. OAR. *Box 3165, Howe, ID 83244.* J.M. SEEGAR. *310 Chestnut Avenue, Towson, MD 21204.* W.S. SEEGAR.

*Chemical Research Development and Engineering Center, Aberdeen Proving Ground, MD 21010.* W.G. MATTOX. *Greenfalk Consultants, Box 29403, Columbus, OH 43229.* T.L. MAECHTLE. *3410 East Columbia, Meridian, ID 83642*

Long-term research in Greenland has yielded 18 years of incidental sightings and 2 years of surveys and observations of gyrfalcons (*Falco rusticolus*) around Sondrestromfjord, Greenland. Gyrfalcons nest on cliffs along fjords and near rivers and lakes throughout our 2590 sq. km study area. Nestlings are present mid-June to July. In 1990, we marked one adult female gyrfalcon with a 65 g radio-transmitter to obtain location estimates via the ARGOS polar orbiting satellite system. The unit transmitted 8 hours/day every two days. We obtained 145 locations during 5 weeks of the nestling and fledgling stage of breeding. We collected 1–9 locations/day, with a mean of 4/day. We calculated home range estimates based on the Minimum Convex Polygon (MCP) and Harmonic Mean (HM methods and tested subsets of the data based on location quality and number of transmission hours per day. Home range estimated by MCP using higher quality locations was approximately 589 sq. km. Home range estimates were larger when lower-quality locations were included in the estimates. Estimates based on data collected for 4 hours/day were similar to those for 8 hours/day. In the future, it might be possible to extend battery life of the transmitters by reducing the number of transmission hours/day. A longer-lived transmitter could provide information on movements and home ranges throughout the year.

## USE OF SATELLITE TELEMETRY IN MONITORING BALD EAGLE MOVEMENTS

KRALOVEC, M.L. *Glacier Bay National Park and Preserve, Gustavus, AK 99826.* M.R. FULLER. *Department of the Interior, Bureau of Land Management, Washington, DC 20240.* P.F. SCHEMPF. *Department of the Interior, U.S. Fish and Wildlife Service, Juneau, AK 99802.* M.R. VAUGHAN. *U.S. Fish and Wildlife Service, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060*

Collecting data on broad-scale movements through the use of conventional radiotelemetry can be limited by inaccessible terrain, large daily movements of the marked animal, and environmental factors. However, a bird-borne satellite transmitter can circumvent these problems by allowing the researcher to reliably obtain frequent locations from a distant position. As part of a research study on bald eagle movements in Glacier Bay National Park and Preserve, we attempted to demonstrate the practical application of a bird-borne satellite transmitter in a field situation. In late summer 1991, three adult bald eagles and three nestling eagles (9–10 weeks) were fitted with satellite transmitters. To verify satellite locations, each adult was also fitted with a VHF transmitter and locations were confirmed using ground and aerial searches. All three immature eagles left the natal territory within 3–6 weeks after fledging. Each immature initially moved northeast and then traveled in a southeasterly direction where they were last located 384.4, 109.2, and 17.4 km southeast of their natal territories. Two of the three satellite marked adults traveled 95 km northeast to the Chilkat River for 6 weeks and then returned to their nest territories by 27 January 1992. The third adult remained within its nest territory. While in the study area, all three adult eagles were visually located (3–4 days/week) within a 5 km radius of each satellite location point. Satellite transmitters provided 4–5 locations per day for 229 days. As confirmed by conventional telemetry, the PTTs were effective in monitoring the broad-scale movements of these adult eagles.

## OWLS OF OLD FORESTS OF THE WORLD

MARCOT, B.G. *USDA Forest Service, PNW Research Station, Spotted Owl RD&A Program, 333 SW First Ave., P.O. Box 3890, Portland, OR 97208*

A review of literature on habitat associations of owls of the world revealed that approximately 84 species of owls among 18 genera are known or suspected to be associated with old forests. Old forest is defined as old-growth or undisturbed forests, typically with dense canopies. The 84 owl species include 72 tropical and 12 temperate forms Specific habitat associations have been studied for only 12 species (7 tropical and 5 temperate), whereas 73 species (65 tropical and 8 temperate) remain mostly unstudied. Some 25 species (35% of all known or suspected old-forest-associated owls in the tropics) are entirely or mostly restricted to tropical islands. Threats to old-forest-associated owls include alteration of habitat, use of pesticides, loss of riparian gallery forests, and loss of cavity nests. Conservation of old-forest-associated owls should include 1) inventories and studies of habitat associations, particularly in poorly studied tropical and insular environments; 2) protection of specific, existing temperate, and tropical old forest tracts; and 3) studies to determine if reforestation and vegetation manipulation can restore or maintain habitat conditions.

## BARN OWL REPRODUCTION AND ITS CONSTRAINTS NEAR THE LIMIT OF THE SPECIES' DISTRIBUTION

MARTI, C.D. *Department of Zoology, Weber State University, Ogden, UT 84408-2505*

I studied reproduction of the barn owl (*Tyto alba*) in irrigated farmlands of northern Utah over 16 years. Three hundred and ninety-one nesting attempts, all in man-made structures, were documented. Most barn owls began nesting at one year of age and produced one brood per year. Rarely, second broods were produced or failed first clutches were replaced. Average size of complete first clutches

($N$ = 275) was 7.17 eggs. Replacement (5.81, $N$ = 16) and second clutches (5.80, $N$ = 19) were significantly smaller than first clutches. Eighty-eight percent of all nesting attempts produced full clutches and 71% yielded at least one fledgling. Mean sizes of first (5.45) and second broods (5.37) were not significantly different but replacement broods (3.83) were significantly smaller. On average, 5.09 young fledged per first brood, 4.94 per second brood, and 3.60 per replacement brood. Second attempts were more likely to produce fledglings than either first or replacement attempts. Sixty-three percent of all eggs laid hatched and 55% produced fledglings. Of eggs that hatched, 88% survived to fledging. March 13 was the mean date for initiation of egg laying and latest second clutches hatched on October 4. Persistent snow cover and low winter temperatures significantly delayed onset of egg laying and reduced the number and success of breeding attempts annually. Clutch size, however, did not differ significantly among years or among nest sites. Most barn owls bred only once, but if both individuals of a pair survived into subsequent breeding seasons, pairs typically remained intact. Most mortality occurred in winter due to a combination of exposure and starvation.

## POST-FLEDGING MORTALITY: A SURVIVAL BOTTLENECK FOR PRAIRIE FALCONS?

MCFADZEN, M. *Department of Biology, Utah State University, Logan, UT 84322.* J.M. MARZLUFF. *Greenfalk Consultants, 8210 Gantz Avenue, Boise, ID 83709*

We studied the cause and frequency of mortality on prairie falcons (*Falco mexicanus*) during the 1992 post-fledging period in Idaho's Snake River Birds of Prey Area. We instrumented 78 nestlings from 19 broods with 6-g tarsal-mount transmitters and monitored their survival until they dispersed from the natal territory. Overall, 28% ($N$ = 22) of fledged falcons died before dispersal (mean mortality age = 41 d, range = 32.5–60.5 d). Predation by great horned owls (*Bubo virginianus*) and golden eagles (*Aquila chrysaetos*) accounted for 36.3% of the mortality and ectoparasite infestations were implicated in 18.2% of the mortality. We could not determine the causes of 45.5 percent of all mortality because carcasses were scavenged and/or decomposed. Parental attendance (% time spent in the territory) and prey delivery rates (prey items/hr) during late brood rearing ($N$ = 11 broods) were not correlated with post-fledging mortality. There was a trend ($P$ = 0.054) for broods that hatched later in the season to experience higher mortality than earlier hatched broods. Survivorship was not correlated with nestling weight or brood size. Post-fledging mortality is relatively high and appears to occur randomly.

## STATUS OF WINTERING BALD EAGLES IN WASHINGTON WITH EMPHASIS ON THE NORTH CASCADE DRAINAGES (1982–90)

MCSHANE, M.C., AND D.A. DELLASALA. *EBASCO Environmental, 10900 NE 8th Street, Bellevue, WA 98004-4405.* R. TAYLOR. *Washington Department of Wildlife, 600 Capitol Way North, Olympia, WA 98501-1091*

The number of bald eagles nesting in Washington has recently met or exceeded the goals outlined in the Recovery Plan for most of the management zones in the state. As a result, the U.S. Fish and Wildlife Service is currently considering removing the bald eagle in Washington from the federal list of threatened species. Although the number of successful nesting pairs and productivity are probably the best way to determine the status of the bald eagle population in a given state, the ability to sustain wintering eagles has implications for breeding populations that occur well beyond state boundaries. Consequently, the objective of this paper is to summarize the status of wintering bald eagles in Washington from 1982, when the mid-winter counts were standardized, to the present (1990). Trends in peak counts for this period were evaluated for the entire state, different regions, and individual drainages or areas of high concentration. A preliminary analysis indicated that the peak winter bald eagle counts from the Skagit River represented 23% of the state total in 1989. Particular emphasis was, therefore, placed on assessing the contribution of each of four major drainages in the North Cascades (Nooksack, Skagit, Stillaguamish, and Skykomish rivers) to the overall state totals. Peak winter counts of bald eagles in the Skagit River Bald Eagle Natural Area were found to be significantly correlated to chum salmon escapement for the Skagit drainage, and a similar analysis was applied to the other drainages. Results can be applied to the management of core bald eagle wintering areas and primary prey concentrations in the state.

## THE ELUSIVE CARACARA: PRELIMINARY INFORMATION FROM SOUTH CENTRAL FLORIDA

MORRISON, J.L. *Department of Wildlife and Range Sciences, 118 Newins-Ziegler, University of Florida, Gainesville, FL 32611*

Investigations were conducted on the feasibility of studying the Crested Caracara (*Polyborus plancus*) in Florida, which occurs as an isolated population and which presently is listed as threatened at both the state and federal levels. Currently, the major threat to the caracara's persistence in Florida appears to be habitat loss through conversion to citrus groves, development, and other agricultural uses. This study was initiated partly as an evaluation of the value of cattle ranches, which cover extensive areas in southcentral Florida, to native wildlife. As grassland habitats, these ranches may be some of the few remaining areas that provide suitable habitat for caracaras. Recently, a successful trapping technique has been developed, resulting in the capture and marking of several individual birds, in anticipation of further long-term studies. Data

obtained from banded and radio-tagged individuals provided preliminary information on activity patterns, foraging behavior, and interactions with other avian scavengers.

HABITAT VARIATION AND POPULATION REGULATION IN THE EUROPEAN SPARROWHAWK *ACCIPITER NISUS*

NEWTON, I. *Institute of Terrestrial Ecology, Monks Wood Experimental Station, Abbots Ripton, Huntingdon, PE17 2LS, Cambs., UK*

This paper will relate territory occupancy and breeding success in *Accipiter nisus* to the age and structure of the forest. Both measures of performance were best in young forest (20–30 years) and deteriorated as the forest aged. In forests older than 40 years, reproduction was insufficient to offset mortality. Population persistence was thus dependent on the continued presence of young forest.

HOME RANGE DISTRIBUTION AND HABITAT USAGE OF RED-TAILED HAWKS AND RED-SHOULDERED HAWKS DURING DORMANT SPRAY SEASON IN THE CENTRAL VALLEY

OTTUM, N.D., D.M. FRY, B.W. WILSON AND J.T. YAMAMOTO. *Department of Avian Sciences, University of California, Davis, CA 95616.* J.N. SEIBER AND M.M. MCCHESNEY. *Department of Environmental Toxicology, University of California, Davis, CA 95616*

Habitat usage and distribution of wintering hawks in a 52 sq. mi. area in the central valley of California were analyzed to look at pesticide exposure during the winter dormant spray season. Thirty-six Red-tailed hawks (*Buteo jamaicensis*) and four Red-shouldered hawks (*B. lineatus*) were trapped and equipped with backpack-style radio transmitters during December and January, 1990–92 near Modesto. Tagged birds were randomly located on a daily basis for daytime habitat use information and periodically located by triangulation at night to determine roost sites. The GIS program CAMRIS was used to calculate home ranges by the density surface method and grid size selection was based upon hunting behavior of the birds. Home range analysis indicated a preference of some birds to use orchards exclusively while others preferred open habitat. Of the 28 birds establishing winter ranges, 12 remained as residents. Data suggest that selection of habitat was influenced by the numbers of resident birds, orchard irrigation techniques, orchard age, and degree of human disturbance. Five radio-tagged birds are known dead: three of the deaths were due to electrocution, gunshot, and automobile collision; one band was returned from northeastern Oregon with cause of death unknown; and the last bird was decomposed too badly for diagnosis. Supported by the Almond Board of California.

DIETARY AND ENERGETIC ANALYSIS OF BAT FALCON PAIRS DURING THE BREEDING SEASON IN TIKAL, GUATEMALA

PARKER, M. *RRTAC, Department of Biology, 1910 University Drive, Boise State University, Boise, ID 83725*

Four pairs of bat falcons, *Falco rufigularis,* were observed in lowland primary rain forest in northern Guatemala's Tikal National Park during 1991. Day-long observations at all nests and daily prey remains and pellet collection at one nest revealed differences in prey species, foraging habits, and rates across the breeding season. Differences in habitat were reflected in dietary differences between nesting pairs. Seasonal precipitation offered pulses of ephemeral insect prey, which accounted for a substantial percentage of their diets, nearly exclusively during stages of brooding. Novel foraging behavior was observed and energetic costs were estimated for one pair, whose foraging flights could be observed in near entirety.

USE OF GOSHAWK STICK NESTS BY GREAT GRAY OWLS ON THE TARGHEE NATIONAL FOREST

PATLA, S.M. *Department of Biological Sciences, P.O. Box 8007, Idaho State University, Pocatello, ID 83422*

Between 1990 and 1992, over 30 new Great Grey Owl breeding territories have been documented on the Targhee National Forest in southeastern Idaho. The majority of these territories have been found in conjunction with an ongoing goshawk monitoring project and occur in Douglas-fir and mixed conifer habitat. Of 64 identified goshawk nests, 14 (22%) have been used by nesting owls. Nine of these 14 nests (64%) have been used following some level of timber harvest activity in the surrounding area. This paper will compare nest site characteristics between stick nests used by goshawks with those used by both hawks and owls. Potential effects of timber harvesting on nest site availability for both species will be discussed.

PEREGRINE FALCON RESTORATION IN THE MIDWEST: 1992 STATUS REPORT

REDIG, P.T. AND H.B. TORDOFF. *The Raptor Center and Bell Museum of Natural History, University of Minnesota, 1920 Fitch Avenue, St. Paul, MN 55108*

1992 marked the tenth year of releases of captively propagated peregrine falcons into the midwestern section of the United States. A total of 111 falcons were released at six sites, bringing the total number released over ten years to 773. States or provinces included in this assessment are Minnesota, Wisconsin, Iowa, Michigan, Illinois, Indiana, Ohio, Missouri, Nebraska, and Manitoba (Canada). Occupancy and productivity at sites occupied by returning adults were consistent with earlier projections based on population modeling. A total of 26 sites was occupied and a total of 65 young was fledged. Among this total were 13

eyases that were fostered into wild nests from domestic sources of falcons. The combined fledging success was 2.6 y/attempt and 2.96 y/successful pair. Adult survivorship, nest-site and mate fidelity, and genetic relationships were monitored by positive determination of identities of adults and DNA fingerprinting. Plans for release by hacking at several sites were preempted by territorial juvenile or adult pairs. Given the productivity and stability of this restored population, it is likely that hacking of falcons will occur at a greatly diminished level in 1993 and cease altogether thereafter.

### MANAGEMENT RECOMMENDATIONS FOR THE NORTHERN GOSHAWK IN THE SOUTHWESTERN UNITED STATES

REYNOLDS, R. *Rocky Mountain Forest and Range Exp. Station, 240 West Prospect, Fort Collins, CO 80526.* R.T. GRAHAM. *1221 South Main, Moscow, ID 83843.* M.H. REISER. *Heber Ranger District, P.O. Box 968, Overgaard, AZ 85933-0968.* R.L. BASSETT. *USDA Forest Service, 517 Gold Avenue SW, Albuquerque, NM 87102.* P.L. KENNEDY. *Department of Fishery and Wildlife, Colorado State University, 241 Wagar Hall, Fort Collins, CO 80523.* D.A. BOYCE, JR. *USFS Wildlife and Fisheries, 517 Gold Avenue SW, Albuquerque, NM 87102.* G. GOODWIN. *Coconino National Forest, 2323 E. Greenlaw Lane, Flagstaff, AZ 86004.* R. SMITH. *Coronado National Forest, Federal Building, 300 West Congress, Tucson, AZ 85701.* E.L. FISHER. *USFS Wildlife and Fisheries, 517 Gold Avenue SW, Albuquerque, NM 87102*

Recommendations for managing goshawk habitat in three forest cover types (ponderosa pine, mixed conifer, and spruce-fir) are described in detail. The recommendations were developed based upon the known habitat requirements of goshawks and 14 important prey species. Although the management strategy is focused on forests in the southwestern United States, these multi-species management recommendations have the related benefit of being applied across the western landscape, not just within goshawk territories. A strength of the management approach is the recommended return to pre-settlement-like forest conditions. This entails a gentler management approach that retains large areas of mid-aged (80–120 years) to old forests (200+ years) across the landscape.

### DISTRIBUTION AND HABITAT CHARACTERISTICS OF MEXICAN SPOTTED OWLS IN ZION NATIONAL PARK, UTAH

RINKEVICH, S.E. *USDA Forest Service, Dixie National Forest, 82 N. 100 E., P.O. Box 580, Cedar City, UT 84721*

Distribution, habitat characteristics, and food habits of the Mexican spotted owl (*Strix occidentalis lucida*) were investigated in Zion National Park. Two hundred and twenty-nine surveys were conducted in canyon and plateau habitat between May–August 1989 and April–August 1990. I located owls in nine different locations; each owl was associated with narrow canyons, "hanging" canyons, and cliff sites. The minimum estimated density in Zion National Park was 0.02 owls/km$^2$ in 1989 and 0.03/km$^2$ in 1990. Spotted owls were widely distributed and coincident with discontinuous habitat within the park. I used stepwise discriminant analysis to examine the habitat differences between 1) observed owl microsites and available microsites and 2) observed owl canyon habitat and available canyon habitat. Spotted owl microsites had higher humidity, more vegetation strata, narrower canyon widths, and higher percentage of ground litter than available microsites. Habitat within owl use canyons had higher humidity and higher total snag basal area than available canyon habitats. Owls may be selecting canyon habitat not only for the structural habitat features but also for the microclimate. The presence of canyons and cliffs may provide necessary refuges from high daytime temperatures that occurred in the study area. Mexican spotted owls do not appear to depend on extensive stands of old-growth forests as do northern spotted owls (*S. occidentalis caurina*) because this type of habitat is lacking in Zion Park. Seventy-one prey items were identified from 60 pellets collected from two owl territories. Mammals comprised 99.9% of estimated biomass and 80.3% of the total diet composition. Bushy-tailed woodrats (*Neotoma cinerea*) were the primary prey taken by owls. They comprised 67.3% of the estimated biomass and 40.3% by frequency of the diet. Further studies are needed to investigate the habitat requirements of the spotted owl in the northern region of its range.

### RESPONSE OF GREAT HORNED OWLS TO MANIPULATIONS OF PREY DENSITIES IN THE BOREAL FOREST

ROHNER, C. *Department of Zoology, University of British Columbia, 6270 University Boulevard, Vancouver, B.C., Canada V6T 1Z4 and Kluane Lake Research Base, Mile 1054 Alaska Highway, Yukon, Canada Y1A 3V4*

Foraging theory and models of territoriality predict that an animal will travel less when food is abundant and that its home range size will decrease. This concept is often applied to interpret movement and home range data in wildlife biology, although little experimental evidence exists for larger animals. A collaborative project near Kluane Lake in the southwestern Yukon was designed to investigate the interactions of animal populations of different tropic levels in the boreal forest ecosystem. Experimental food additions to snowshoe hares and ground squirrels resulted in up to 20 times higher densities on areas of 0.5–1 km$^2$. Two owls on territories with increased prey levels were chosen as experimental birds and radiotelemetry was used to compare them to 4 controls. Despite the extreme contrast in prey base, no differences in movement rates and home range sizes were apparent. This suggests caution for the general use of these measures as standard management tools. Can the sampling be refined, or does the concept not apply to our organisms? This question is open at the moment. One explanation is that the predictions from theory have been derived for an animal that searches randomly through homogeneous habitat. Great horned owls

as typical perch hunters seem to be using a network of distinct hunting spots, rather than diffuse searching. The response would, therefore, not be strictly area dependent, but dependent on the specific location of these "hot spots" in the territory—a model that may also apply to other perch-hunting owls and raptors. A link to another result is interesting: during the course of a snowshoe hare cycle, the size of long-term territories was determined by intruder pressure, and not by food. Great horned owls, as a long-lived species, may try to maintain as large territories as possible in every situation.

## RELATIONSHIPS OF MICROCLIMATE AND MICROHABITAT TO AMERICAN KESTREL NEST-BOX USE AND NESTING SUCCESS

ROHRBAUGH, JR., R.W. AND R.H. YAHNER. *School of Forest Resources, The Pennsylvania State University, University Park, PA 16802*

American kestrels (*Falco sparverius*) use nest-boxes in a non-random fashion and experience differential nesting success among boxes. Non-random use and differential success are presumably caused by environmental factors external to the box itself. Our objective was to determine if microclimatic and microhabitat characteristics associated with nest-boxes influenced nest-box use and nesting success. This research is important in determining how environmental factors influence the use patterns and nesting success of avian species using artificial nest sites. We measured internal reflected light intensity (IRLI), internal mean temperature (IMTE), percent nest-box concealment (NBCO), and nest-box orientation (NBOR) associated with 130 nest-boxes in southeastern Pennsylvania during 1991. We then compared these microclimatic and microhabitat characteristics to nest-box use patterns and nesting success observed during a five-year period (1987–91). The means (±SE) for IRLI, IMTE, NBCO, and NBOR were 5.9 ma (0.17), 21.7°C (0.28), 37% (3.00), and 157° (10.40), respectively. We used analyses-of-variance (ANOVA) and chi-square tests-of-independence to test for differences in microclimatic and microhabitat characteristics among levels of nest-box use and nesting success. We found nest-box use to be significantly influenced ($P \leq 0.05$) by IRLI, NBCO, and NBOR, whereas nesting success was influenced by IRLI alone. IRLI increased with increasing frequency of nest-box use ($F = 4.11$, $P = 0.02$), while NBCO decreased with increasing frequency of box use ($F = 3.02$, $P = 0.05$). Thirty-eight percent of the frequently used nest-boxes (boxes used ≥3 of 5 years) were oriented southeast ($\chi^2 = 14.64$, df $= 6$, $P \leq 0.025$). Nesting success increased with increasing IRLI ($F = 3.15$, $P = 0.04$). IMTE was not significantly different among levels of nest-box use or nesting success. These results will be used to develop a habitat model for the placement of nest-boxes in optimal habitat for American kestrels.

## EYE COLOR OF COOPER'S HAWKS BREEDING IN WISCONSIN

ROSENFIELD, R.N. *Department of Biology, University of Wisconsin, Stevens Point, WI 54481.* J. BIELEFELDT. *Park Planning, Racine County Public Works, Sturtevant, WI 53177.* K.R. NOLTE. *Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&I University, Kingsville, TX 78363*

Though several authors have noted the progressive changes in eye color with age in North American accipiters, no studies have published such detailed information on eye color for a breeding population of marked birds. We use eye color recorded during 377 captures of 253 different breeding adult Cooper's Hawks (*Accipiter cooperii*) in Wisconsin over 13 years to examine the relationships of eye color with age, gender, and male fitness. In both sexes, eye color showed a progressive change from lighter yellow in younger hawks to dark orange or red in older birds. Males had darker eyes than females of the corresponding age. We found no support for the hypothesis that male fitness is associated with male eye color. We also discuss how our data on eye color are useful for elucidating aspects of the population ecology (including nest-site tenacity) of breeding Cooper's Hawks.

## HOW ARE DECISIONS ABOUT THE INFLUENCE OF HUMAN ACTIVITIES ON RAPTORS INFLUENCED BY ABIOTIC FACTORS?

SCHUECK, L. AND J.M. MARZLUFF. *Greenfalk Consultants, 8210 Gantz Ave., Boise, ID 83709*

Observer motivation, visibility, and animal activity are influenced by abiotic factors such as extreme temperatures, wind, and precipitation. Therefore, counts of abundance and quantification of behavior are likely to be dependent upon prevailing abiotic factors. Failure to account for these factors in assessments of human impact can result in misleading conclusions about the severity of impact and produce dubious management recommendations. We illustrate this problem with examples from our ongoing study of the potential impacts of military training on raptor behavior in the Snake River Birds of Prey Area. We counted raptors utilizing training ranges during periods of firing and during periods without firing. Climatic conditions were measured with portable "Weather Wizard" stations and found to correlate significantly with raptor abundance. Climate varied within and between observation sessions and therefore influenced our counts of raptors to an unknown degree. We statistically controlled for weather-related bias in our analyses by using weather variables as covariates in our comparisons of raptor abundance on firing and non-firing days. These analyses allowed us to conclude that intensive military training reduced the number of raptors in the immediate training area in 3 of 4 tests. Failure to control for variation in climate reversed our conclusions in 2 of 4 tests; one significant result con-

trolling for weather was not significant when weather was not controlled and one nonsignificant result became significant. Reversal of significance was less likely in large samples pooling data from more than one year. We conclude that abiotic conditions suspected to influence observers or subjects must be identified, measured, and controlled during impact studies to prevent incorrect assessment of disturbance.

PEREGRINE POPULATION DYNAMICS IN WEST-CENTRAL GREENLAND

SEEGAR, W.S. *Chemical Research, Development and Engineering Center, Aberdeen, MD 21010.* W.R. GOULD. *Department of Statistics, North Carolina State University, Raleigh, NC 27695.* M.R. FULLER. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708.* W.G. MATTOX. *Greenland Peregrine Falcon Survey, 307 Blandford Avenue, Worthington, OH 43085.* M.A. YATES, T.L. MAECHTLE, J. OAR AND M. ROBERTSON. *Virginia Polytechnic Institute and State University, Blacksburg, VA 24061*

Peregrine falcons around Sondrestrom Fjord were studied to document their population dynamics during recovery efforts for this endangered species. Capture probabilities, survival estimates, and population estimates were obtained from color-banded adult females. Program JOLLY provided the basis for analyses and model D was selected to generate the estimates. From 1983 to 1991, our capture probability was 97.8% and the annual survival was 78.0%. The assumptions associated with these models are discussed in light of the fieldwork, birds' biology, and interpretation of results. Yearly population estimates were standardized based on sampling effort. A significant increase in the population occurred during the 9-year study.

MANAGEMENT OF THE THREATENED SOUTHEASTERN AMERICAN KESTREL IN FLORIDA: POPULATION RESPONSES TO A REGIONAL NEST-BOX PROGRAM

SMALLWOOD, J.A. *Department of Wildlife and Range Sciences, University of Florida, Gainesville, FL 32611.* M.W. COLLOPY. *U.S. Bureau of Land Management, 3200 SW Jefferson Way, Corvallis, OR 97331*

The resident population of Southeastern American Kestrels (*Falco sparverius paulus*) declined by over 80% in northcentral Florida during recent decades. Similar declines occurred throughout the state and this subspecies currently is listed as threatened in Florida. A statewide decrease in the availability of suitable cavity trees, isolated or scattered pine snags in open habitats, was closely correlated with the decline in the number of breeding pairs. The objectives of this study were 1) to evaluate the effect that increasing the availability of nesting sites has on kestrel population densities in northcentral Florida, and 2) to develop a strategy for selecting specific nest-box locations. In order to monitor population densities, kestrels were censused each August, 1989 to 1992, along 20 16-km roadside transects in northcentral Florida. In 1989, prior to erecting nest-boxes, population densities ranged from 0 to 0.83 kestrels/km$^2$. A total of 336 nest-boxes subsequently was erected within 10 km of 10 transects with low kestrel densities; the 10 transects with the highest initial densities served as controls. Census data from 1989 through 1992 revealed that mean densities along the control transects did not change significantly with time, while mean densities along experimental transects increased geometrically; three of the four highest densities observed in 1992 occurred along experimental transects. Recommendations for selecting nest-box locations were developed by quantifying the habitat surrounding active nest-boxes (those in which kestrels bred) and nearby inactive nest-boxes, and examining the association of kestrel occupancy rates and breeding success with vegetative structure and land use patterns.

THE EFFECT OF PREY AND WEATHER ON GOLDEN EAGLE REPRODUCTIVE RATES

STEENHOF, K. AND M.N. KOCHERT. *RRTAC, Bureau of Land Management, Boise, ID 83705*

We studied golden eagle (*Aquila chrysaetos*) populations nesting in the Snake River Canyon from 1971 through 1991, and analyzed eagle reproduction in relation to black-tailed jackrabbit (*Lepus californicus*) populations and several weather variables. The best predictor of eagle productivity was jackrabbit abundance prior to the breeding season. Winter weather (as expressed by heating degree days during December and January) was associated with eagle productivity primarily when jackrabbit populations were low; cold winter temperatures were associated with reduced numbers of eagle pairs that laid eggs. Hatching dates were inversely related to jackrabbit density, but were not associated with winter weather variables, even in low jackrabbit years. Extreme heat during brood-rearing was associated negatively with eagle nesting success in years with low jackrabbit populations.

THE USE OF MAN-MADE STRUCTURES FOR RED-TAILED HAWK NEST SUBSTRATES IN SOUTHEAST WISCONSIN

STOUT, W.E. AND R.K. ANDERSON. *University of Wisconsin–Stevens Point, Stevens Point, WI 54481.* J.M. PAPP. *Rt. 1, Box 158A, Drummond, WI 54832*

Raptors commonly nest on powerline towers in the western United States. This phenomenon usually occurs on open plains, prairie, or savannah, and is attributed to the absence of suitable nest sites. In the eastern U.S. and Canada, Osprey are the only raptor that commonly nest on powerline towers. In southeast Wisconsin, Red-tailed Hawks almost exclusively nest in deciduous trees. There is only one report of two successful Red-tailed Hawk nests on

power poles in the eastern U.S. in Polk County, Florida. A nest is successful if it fledges at least one young. We documented five successful Red-tailed Hawk nests on man-made structures (four 230-kV transmission towers and one billboard) in southeast Wisconsin in 1992. Three were successful in 1991 and two in 1990. Nests and structures were higher and closure at the nest was more open than traditional sites in the region. No overstory trees were present in a 0.04-ha circular plot centered on the nest site. Nesting Red-tailed Hawk populations in the Midwest increased over the last four decades. In 1992, sixteen redtail pairs nested in urban habitat in the metropolitan Milwaukee area of southeast Wisconsin. For this study, a nest site is considered urban if 70% or more of the land within a 1.5 km radius of the nest is being used for industrial or residential purposes. The relationship between increased Red-tailed Hawk populations and changes in land-use patterns needs to be studied and could be beneficial for the development of new raptor management techniques in urban areas. Nesting on man-made structures may compensate for, and be in response to, decreased natural nesting habitat and changes in land-use patterns such as increased urbanization and monotypic agricultural practices.

### RELATIVE ABUNDANCE AND NEST SITE SELECTION OF RED-SHOULDERED HAWKS (*BUTEO LINEATUS*) NESTING WITHIN FLOODPLAIN FORESTS IN POOLS 9–11 AND 16–19 OF THE UPPER MISSISSIPPI RIVER VALLEY

STRAVERS, J.W. *Iowa Raptor Foundation, P.O. Box 32, Pella, IA 50219.* D.M. ROOSA. *Iowa Department of Natural Resources, Wallace State Office Building, Des Moines, IA 50309*

During the spring of 1992, we searched 101 areas within the Upper Mississippi River Valley for evidence of nesting Red-shouldered Hawks (RSH), which are considered endangered, threatened, or of special concern in most midwestern states. We documented or suspected RSH nesting in 27 of the 62 areas searched in Pools 9–11 (McGregor District). This district has had a comprehensive forest and wetland management plan which limited timber harvest and the construction of artificial levees since the late 1930s. In contrast, we documented or suspected RSH nesting in only five of the 42 areas searched in Pools 16–19 (Wapello District). This district has not had a comprehensive forest management plan and it has a series of elaborate levee systems restricting the river. At the active RSH nest sites we measured the distance to nearest stream, main channel of the Mississippi River, ridge, road, railroad track, human dwelling, agricultural field, levee, and logging activity. We compared RSH nest sites to random sites selected within the river valley. All RSH nesting sites were located in forest tracts where the overhead canopy was well-developed, in areas that had no logging activity for 45–55 years. All nest sites were within 200 m of a temporary pool, small stream, or the confluence of two streams. In contrast, no RSH nesting sites were found within 800 m of the main channel of the Mississippi River, nor were any found in apparently suitable forest habitats which were bordered by levees and agricultural fields.

### THE U.S. FISH AND WILDLIFE SERVICE'S STATUS REVIEW OF ARCTIC PEREGRINE FALCONS

SWEM, T. AND S. AMBROSE. *U.S. Fish and Wildlife Service, 1412 Airport Way, Fairbanks, AK 99701*

Arctic peregrine falcon (*Falco peregrinus tundrius*) populations have expanded since the 1970s following restrictions on the use of organochlorines. In 1984, in response to the recovery, the U.S. Fish and Wildlife Service downlisted the status of arctic peregrines from Endangered to Threatened. Later surveys and field research have shown that the recovery has continued. In 1991, the U.S. Fish and Wildlife Service initiated a review of the status of the arctic peregrine falcons throughout North America in order to determine if delisting the subspecies is appropriate. This involved accumulating all the available data on population trends, containments, and migration counts. The purpose of this paper is to provide a brief, continent-wide, overview of the information that has been collected, and to update the RRF on the Fish and Wildlife Service's current management strategy for this subspecies.

### THE USE OF SONOGRAPHIC ANALYSIS IN IDENTIFYING INDIVIDUAL PEREGRINE FALCONS (*FALCO PEREGRINUS*)

TELFORD, E.A. *8300 Gantz Ave., Boise, ID 83709*

Recordings of nesting Peregrine Falcons in the northeastern United States were made in 1989, 1990, and 1991. The "cack" call was recorded because it is a defense call and is therefore easily elicited. Sonograms were generated from the recordings and analyzed for vocal distinctions among individuals. Three frequency and three temporal variables were measured from the sonograms, and two slope variables were derived. Discriminant function analysis on a sample of 406 calls from 17 individuals was able to successfully discriminate among individuals. Multivariate analysis of variance comparing the overall variation of calls among birds to the variation within birds was highly significant ($P < 0.001$).

### USE OF RAPTORS FOR BUILDING LOCAL CAPACITY FOR CONSERVATION IN LATIN AMERICA

THORSTROM, R. AND D. WHITACRE. *The Peregrine Fund, Inc., 5666 West Flying Hawk Lane, Boise, ID 83709*

In 1987, The Peregrine Fund initiated a preliminary trip to Guatemala and Belize to select research locations for the *Maya Project*—a multi-year, community-level project focusing on raptors to achieve conservation of biological diversity and development of local capacity for conservation. Training and education are critical components in

building local capacity and infrastructure in Latin America countries to manage and conserve natural resources. The Maya Project began in 1988 at Tikal National Park in northeastern Guatemala and has expanded each year to date. The project consists of research on natural history of selected raptor species, and a program of monitoring biological diversity of the forest using raptors and other fauna as ecological indicators. Species-level studies involve collecting behavioral, dietary, and telemetry data on raptors. Participants gain much experience in these techniques and receive formal training in ecology and conservation topics. In 1988 the project involved eight local park guards who assisted in the development of raptor and habitat survey techniques. In 1989, one park employee, Julio Madrid, presented a paper at the RRF/ICBP meetings in Veracruz, Mexico. The Maya Project has provided several park guards with scholarships allowing them to finish high school degrees. In 1991, species-level projects were increased; project personnel reached 39 in the park plus 25 outside the park. Julio Madrid of CECON (Centro de Estudios Conservacionistas de la Universidad de San Carlos de Guatemala) became the principal investigator on the Ornate Hawk-Eagle study. In 1991, the Maya Project facilitated participation of two local park guards and one CECON employee in the NOC (Neotropical Ornithological Congress) in Quito, Ecuador, where they presented papers on Swallow-tailed Kites, Mottled Owls, and Ornate Hawk-Eagles. In 1992, several Guatemalans became project leaders for species-level studies on Ornate Hawk-Eagles, Black Hawk-Eagles, Swallow-tailed and Plumbeous Kites, Laughing Falcons, Bicolored Hawks, Collared Forest-Falcons, Barred Forest-Falcons, Mottled Owls, and year-round censuses of raptors as well as heading teams investigating migrant and resident songbirds and vegetation. Hopefully, the training and experience in ecology, scientific research, and conservation that these local people have received will enable them to acquire jobs with the newly developing governmental and non-governmental conservation organizations in the Tikal region, where their knowledge and experience can help create a legacy of enlightened conservation efforts.

## BREEDING BIOLOGY, FOOD HABITS AND HOME RANGE OF THE BARRED FOREST-FALCON (*MICRASTUR RUFICOLLIS*) IN GUATEMALA

THORSTROM, R. *The Peregrine Fund, Inc., 5666 West Flying Hawk Lane, Boise ID 83709.* C. MATEO MORALES. *Institute de Antropologia and Historia, Tikal National Park, Petén, Guatemala, C.A.*

We described the first four nests of the Barred Forest-Falcon (*Micrastur ruficollis guerilla*) in 1988 at Tikal National Park, Guatemala. We studied the breeding biology of the Barred Forest-Falcon from 1989 through 1991. Thirty-two nesting attempts were observed from 1988 through 1991. Barred Forest-Falcons are year-round residents and initiated breeding from April to early June, during the dry season. Seventy-two eggs were laid in 26 nests; average clutch size was 2.7 eggs. The incubation period was 35 days from laying of second egg to first hatch ($N = 6$ nests). Overall, 45% of the eggs hatched and 84% of the young fledged. A total of 1.1 young fledged per breeding attempt. Of 28 fully documented nesting attempts, 13 (46%) produced fledged young; 50% of the first nesting attempts ($N = 26$) produced young, and none of the second attempts was successful ($N = 2$). Most reproductive losses in 15 failed nests resulted from egg and female predation ($N = 13$). Survivability of adult breeding females was less than that for adult breeding males. Food habits were based on 587 prey deliveries during the breeding seasons. On a numerical basis, lizards made up 41% ($N = 240$) and birds 14% ($N = 82$) of the diet. Biomass estimates showed lizards (33.6%) and birds (33.1%) to be the most important prey items delivered. The 85% harmonic-mean home range estimates average 1.1 $km^2$ for 11 breeding males. In a 16 $km^2$ area centered around the main archeological ruins we located 12 breeding pairs and two non-breeding pairs. We learned from radiotelemetry that this species prefers high-ground forest for breeding and foraging; their abundance is much lower in low, open-canopy forest occurring in low-lying parts of the study area. This species has a broad geographical range, lives at high densities, at least in Tikal, occupies a small home range and utilizes mature and old-growth trees for nesting. This species may well be suited as an ecological indicator for lowland dry tropical forests or possibly other types of tropical forests.

## AN INVESTIGATION OF THE GENERAL HEALTH AND CONTAMINANT LEVELS OF MIGRANT SHARP-SHINNED HAWKS IN THE EASTERN FLYWAY

VIVERETTE, C. AND L. GOODRICH. *Hawk Mountain Sanctuary, RR 2, Box 191, Kempton, PA 19529-9449.* M. POKRAS. *Tufts University School of Veterinary Medicine, 200 Westboro Road, North Grafton, MA 01536*

Hawk count stations in the northeastern United States have noted a precipitous decline in Sharp-shinned Hawks (*Accipiter striatus*) since the mid-1980s. The greatest declines have been observed at coastal sites where immature birds comprise 80% of the Sharp-shinned Hawks recorded. Inland count sites, such as Hawk Mountain Sanctuary, where adult birds comprise over 50% of total sharpshins, have only recently begun to note a corresponding decline in this species. The pattern of immatures declining before adults suggests possible widespread reproductive failures. There has been speculation that Sharp-shinned Hawk populations are being adversely impacted by consuming prey contaminated by pesticides. In the fall of 1991, Hawk Mountain conducted a preliminary assessment of the contaminant load of eastern populations of migrating Sharp-shinned Hawks. We analyzed blood samples from migrant

sharpshins and tissue samples from road and window-killed birds for organochlorines, PCBs, and heavy metals. Results from these analyses showed elevated levels of DDE in some adult carcasses. In addition, the average blood level found in adult birds has been shown to correspond to significantly elevated levels of DDE in Sharp-shinned Hawk eggs.

## RESTORING OSPREY TO METROPOLITAN LAKES IN THE TWIN CITIES, MINNESOTA

VOIGHT-ENGLUND, J., M. MARTELL, H. TORDOFF AND P.T. REDIG. *The Raptor Center at the University of Minnesota, 1920 Fitch Ave., St. Paul, MN 55108*

Ospreys historically nested throughout the wooded portion of Minnesota, including the Twin Cities area. They were eliminated as a nesting species in the southern two-thirds of the state before the turn of the century, primarily due to uncontrolled shooting. Ospreys have been successfully reintroduced to portions of their former range in Minnesota through hacking programs. In 1992, a three-year program was initiated to return Osprey as a nesting species to lakes within the metropolitan area, as well as to provide city residents and visitors with the exciting opportunity to see Ospreys at close range. Hack towers were erected at two metropolitan lakes. Osprey chicks were translocated from nests in northcentral Minnesota to metropolitan hack boxes at 5½–7 weeks of age. Birds were released when they reached flight stage. A corps of volunteers (over 75 at the two sites) was enlisted to monitor the fledglings from dawn until dusk for 4 weeks after their release. Ospreys learn to fly and fish without adult supervision. The Twin Cities Ospreys have become tolerant of human activity, including canoeing and walking adjacent to the hack box. The birds use perches in areas of moderate human activity as well as perches in more secluded areas. They fish adjacent to canoes and sailboards. One of the more impressive results of this year's reintroduction was the high degree of interest exhibited by park users. Almost half of the persons visiting the monitoring stations had no previous knowledge of Ospreys and they were extremely enthusiastic about the project after viewing the birds through the monitor's spotted scope. Reintroducing Ospreys to a metropolitan area is an effective method of restoring an ecosystem, as well as educating the general public about raptors, wildlife, general ecological principles, and the human role in natural resources conservation.

## USE OF RAPTORS IN MONITORING ECOLOGICAL INTEGRITY OF TROPICAL FOREST RESERVES

WHITACRE, D. *The Peregrine Fund, Inc., 5666 W. Flying Hawk Lane, Boise, ID 83709.* A.J. BAKER. *P.O. Box 2492, Gig Harbor, WA 98335.* I. CÓRDOVA M. *Parque Nacional Tikal, Petén, Guatemala.* P.M. HARRIS. *4019 Ashworth N., Seattle, WA 98103.* A.E. HERNÁNDEZ C. *Parque Nacional Tikal, Petén, Guatemala.* L.E. JONES. *22583 Veronica Dr., Salinas, CA 93908.* C. MATEO M. *Parque Nacional Tikal, Petén, Guatemala.* J. SUTTER. *22583 Veronica Dr., Salinas, CA 93908.* C. SWARTZ. *1205 Thousand Springs Grade, Wendell, ID 83355.* C.W. TURLEY. *120 S. 24th Street, Mount Vernon, WA 98273.* R. VILLEGAS P. *Apartado Postal 579, Xalapa, Veracruz, Mexico*

To achieve effective conservation within protected areas, it is important to monitor biological diversity and ecological integrity of these areas. Over the past five years, Peregrine Fund researchers have developed methods for monitoring ecological integrity of tropical forest areas, using diurnal and nocturnal raptors and selected other bird and mammal species as ecological indicators. The "Maya Project" uses a suite of census techniques to monitor ecological health of the largest area of contiguous protected lowland forest in Central America—the Maya/Calakmul/Rio Bravo biosphere reserve complex and surroundings, in Guatemala, Belize, and Mexico. At each site, 10 canopy-emergent census points (trees, Mayan temples) are used, with a combination of three census methods. A pre-dawn listening census reveals *Micrastur* spp., owls, nightjars, tinamous, primates, and other species. A mid-morning visual/aural census above the canopy reveals most diurnal raptors, as well as pigeons, doves, and parrots. These methods are supplemented by acoustical luring using distressed prey vocalizations, to increase detection rates of a few cryptic or rare species (Bicolored Hawk, Crested Eagle). These techniques yield various indices of detection rate and relative abundance which can be used to compare habitats or detect change over time. Methods are described, along with pitfalls and practical hints. Results are presented for three areas censused during two years. Differences in raptor communities among the three sites are clearly demonstrated. This suite of methods is a low-tech, flexible, and highly replicable approach to inventory and monitoring of raptors and other potential indicator species in tropical forests. Current rates of tropical forest destruction, degradation, and fragmentation argue for the widespread installation of programs for monitoring biological diversity and ecological integrity. The methods described here should be easily adapted to other sites throughout the world and can play an important role in establishment of effective monitoring programs.

## POST-FLEDGING ECOLOGY OF IMMATURE BALD EAGLES. MOVEMENTS, TIMING OF MIGRATION, AND SURVIVAL

WOOD, P.B. *West Virginia Cooperative Fish and Wildlife Research Unit, P.O. Box 6125, Percival Hall, West Virginia University, Morgantown, WV 26506-6125*

Little was known about the post-fledging movements and habitat use of fledgling bald eagles prior to their first migration. Timing of initial migration and factors that influence it also were not well understood. I used a two-fold approach to address these questions. I collected ex-

tensive data on 44 radio-tagged nestlings from 1987 to 1991 and supplemented these data with intensive observations of nestlings at 2 nests in 1991 in north Florida. Fledgling eagles (birds prior to their initial migration) remained dependent on adults for food and stayed at or near the natal nest until they initiated migration at an average of 7 (4–11) weeks post-fledging. However, by 3 weeks post-fledging, they had ranged outside of the 229 m primary protection zone used in Florida. Of greater importance is the extent of the protection period which currently ends when young fledge. It should extend until fledglings initiate migration away from the natal area. Disturbance near a nest while fledglings still are dependent on adults may cause premature dispersal of young from the nesting area prior to their attaining adequate food reserves for migration. Fledglings in less than optimum physical condition when initiating migration may be less likely to survive the energetic demands of migration. Lowest survival occurred during the first summer of life (63%) shortly after initiation of migration, indicating the importance of fledglings being in good physical condition when they leave the nest area. Timing of migration appeared to relate to food availability and likely, physical condition; most fledglings left the study area while fish abundance was declining. First-hatched birds tended to migrate at a younger age than second-hatched birds. Since the older sibling generally dominated in food conflicts, it could achieve the physical condition necessary for migration more quickly. The younger sibling in two-chick nests also had significantly lower survival (59% vs. 71%) through the first year of life. Prey deliveries decreased at one nest after the older sibling had migrated. Perhaps if young do not leave on their own, food deliveries are decreased by adults, possibly in response to declining prey availability.

### ELECTROCUTION MORTALITY OF GOLDEN AND BALD EAGLES IN AN AREA OF HIGH PREY CONCENTRATION

WOODBRIDGE, B. *USDA Forest Service, Klamath National Forest, 37805 Hwy. 97, Macdoel, CA 96058.* M. GARRETT. *PacifiCorp, 920 SW Sixth Ave., Portland, OR 97204*

We monitored prey abundance, eagle abundance, and eagle mortality in an agricultural valley in northern California from 1986 to 1992. The distribution of eagles within the study area was divided spatially and temporally through the use of two resource systems: 1) blacktailed jackrabbits in sagesteppe habitats during winter and 2) Belding ground squirrels in alfalfa fields during spring and early summer. Eagle concentration during February through May ranged from 4 to 18 eagles per square mile and often exceeded 16 eagles per square mile in areas of alfalfa cultivation. Transect surveys under power distribution lines detected from 4 to 22 eagle carcasses per year in areas of eagle concentration. Initial attempts to retrofit powerpoles to raptorproof standards were largely unsuccessful at preventing mortalities, probably due to the extremely high use of powerpoles by eagles foraging in alfalfa fields. Secondary modifications to poles in eagle habitat will be discussed.

### POSSIBLE FOOD-RELATED EARLY BREEDING OF TWO-YEAR-OLD NORTHERN GOSHAWKS IN SHRUB-STEPPE HABITATS OF NORTHEASTERN NEVADA

YOUNK, J.V. AND M.J. BECHARD. *RRTAC, Department of Biology, Boise State University, Boise, ID 83725*

Northern goshawks normally breed at three years of age. In 1992, 22 pairs of goshawks were found nesting in shrub-steppe habitats in northeastern Nevada that consisted of approximately 10% aspen (*Populus tremuloides*) forest Members of each pair were trapped, color-banded, and aged in the hand. Of these 22 pairs, 11 consisted of mature males mated with two-year-old females. Productivity of adult/adult and adult/two-year-old pairs averaged 3.0 and 2.54 young per pair, respectively. Despite the fact that two-year-old females were as productive as adult females (t-test $P = 0.25$), their dates of fledging young were later (means of June 28 vs. July 5, $P < 0.01$), and more variable (SDs of 5.1 vs. 2.5, $P = 0.038$). These two-year-old females may have begun breeding early because of an abundance of ground squirrels (*Spermophilus beldingi*) in 1992. Blind observations at eight nests showed that breeding goshawks of all ages preyed almost exclusively on these ground squirrels until July when young were approaching fledging age. At this time, estivation of ground squirrels and the increasing abundance of recently fledged young of various species of birds may have caused the shift from ground squirrels to birds such as northern flickers (*Colaptes auratus*), robins (*Turdus migratorius*), and black-billed magpies (*Pica pica*).

## POSTER PRESENTATIONS

### AN ALTERNATIVE TRAPPING METHOD FOR BURROWING OWLS

BANUELOS, G. *H.T. Harvey and Associates, P.O. Box 1180, Alviso, CA 95002*

In order to trap a large population of Burrowing Owls within a short period (two weeks), a trapping method incorporating a one-way door surrounded by a wire mesh cage was used at a construction site in Manteca, California in July 1992, and at a site in Santa Clara, California in August 1991. Wire cages (2′ × 2′) were placed over burrow entrances with one-way doors that allowed owls to exit burrows and enter the trap. Traps were set at occupied burrows and monitored at hourly intervals. At a Manteca site on 14 July, six owls were captured at three trap sites during a time span of two hours and fifteen minutes (2015–2231). On 16 July, three owls were captured at two trap

sites (two owls in one trap) during a time span of four hours (1715–2115). At a Mission College construction site in Santa Clara, California, two owls were caught at one trap during a one hour and twenty-three minute time span (2042–2205) on 7 August. The following day, two owls were captured at two trap sites during a two hour and fifteen minute time span (2300–0115). The ease of constructing and setting the trap, the potentially high capture rate, and the lack of trapping injuries allow the one-way door trap to be used as an alternative to Bal-chatri, noose carpets, and padded leg-hold traps.

## DIRECTIONS AND PRIORITIES FOR RAPTOR RESEARCH IN THE WESTERN UNITED STATES

BEDNARZ, J.C. *Raptor Research Center, Boise State University, Boise, ID 83725.* S.W. HOFFMAN. *HawkWatch International, P.O. Box 35706, Albuquerque, NM 87176*

We initiated an assessment of the priorities of potential research directions to furnish a framework that would help guide future research on western raptors. We solicited input by means of a survey of opinions sent to a representative sample of established raptor specialists throughout North America. A total of 27 responses was received and summarized. Most respondents to our survey favored emphasizing priority research on the species of most critical conservation need rather than on essential general research questions. Specifically, participants advocated that research efforts be focused on declining species and species of unknown status. On the basis of recommendations received and review of the literature, we classified all western raptors into one of three priority categories. Species that were ranked in the highest priority category include the California Condor, Northern Goshawk, Ferruginous Hawk, Golden Eagle, Northern Pygmy-Owl, Mexican Spotted Owl, Boreal Owl, and Ferruginous Pygmy Owl. Based on the survey results and our own familiarity with the state of raptor research, we classified 15 general research topics into one of three priority categories. The respondents to our survey overwhelmingly identified three topics that should receive greatest research emphasis: 1) develop accurate monitoring techniques, 2) monitor population numbers, and 3) determine habitat affinities and needs. Finally, we ranked the priority of several specific topics related to developing reliable monitoring techniques. Of foremost importance is research designed to determine the validity and sensitivity of various existing and proposed monitoring approaches. We suggest that current and future studies that involve both species and research topics in the highest priority categories will likely represent significant contributions to the understanding and conservation of western raptors.

## BEHAVIORAL INTERACTIONS WITHIN A BREEDING PAIR AND OFFSPRING OF MISSISSIPPI KITES (*ICTINIA MISSISSIPPIENSIS*)

BOTELHO, E.S. *P.O. Box 300001/Department 3AF, Department of Biology, New Mexico State University, Las Cruces, NM 88003.* A.L. GENNARO. *Station #33, Department of Biology, Eastern New Mexico University, Portales, NM 88130.* P.C. ARROWOOD. *P.O. Box 300001/ Department 3AF, Department of Biology, New Mexico State University, Las Cruces, NM 88003*

A single Mississippi Kite (*Ictinia mississippiensis*) nest with two nestlings was studied from hatching to fledging. Six nestling behaviors are examined in relation to days or weeks from hatching. Parental care was carried out by both parents throughout the nestling period. The male provided more food to both nestlings than did the female. Nestlings consumed similar amounts of food over the duration of the nestling period. Allopreening, setting the nest, and working the nest were observed among the nestlings Intra-nestling aggression occurred with the younger chick exhibiting almost as many aggressive pecks against the older chick as vice versa. These data suggest that the Mississippi Kite's, and perhaps other kites', pattern of parental care and nestling behaviors may be quite different from that of other raptors.

## FIRE SUPPRESSION AND MANAGEMENT OF SPOTTED OWL HABITAT IN THE WENATCHEE NATIONAL FOREST

BUCHANAN, J.B. *NCASI, 720 SW 4th, Corvallis, OR 97339 (Present Address: Washington Department of Wildlife, 600 Capitol Way N., Olympia, WA 98504).* L.L. IRWIN. *NCASI, 720 SW 4th, Corvallis, OR 97339*

Historically, fire was the most significant disturbance factor in the mixed-conifer forests of the east slope of the Cascade Mountains in Washington. Prior to fire suppression, low-intensity ground fires generally occurred at intervals of less than 50 years across much of the landscape in this region. These short fire intervals prevented the establishment of fire avoiders such as grand fir (*Abies grandis*). During the recent period of fire suppression, a much longer fire interval has influenced stand structure and species composition, resulting in forest stand conditions suitable for occupancy by Spotted Owls (*Strix occidentalis*). Concomitantly, suppression of frequent, low intensity fires has enhanced conditions for stand-replacement fire by increasing fuel accumulations and continuity. In the Wenatchee National Forest (WNF), Spotted Owls appear to nest exclusively in forests naturally regenerated following fires of varying intensity and magnitude. About half of the known Spotted Owl nests occur in even-aged stands 65–135 years old. Most of these stands are dominated by Douglas-fir (*Pseudotsuga menziesii*), although grand fir is present at nearly all sites and typically ranks second in terms of tree abundance and basal area. In addition, 23% of the nest sites had been partially harvested, apparently several decades prior to our study. Priority fire protection has been recommended for sensitive forest habits

used by threatened and endangered species. However, given the forest history and stand conditions in the WNF, we see the need for a more proactive landscape management strategy that will eventually incorporate natural fire regimes and various timber harvest procedures. Adaptive management experiments designed to evaluate these procedures are required to reduce the risk of catastrophic wildfire.

EXPERIMENTAL MANIPULATION OF MANAGED STANDS TO PROVIDE HABITAT FOR SPOTTED OWLS AND TO ENHANCE PLANT AND ANIMAL DIVERSITY

CAREY, A.B. AND L. WUNDER. *USDA Forest Service, Forestry Sciences Laboratory, Pacific Northwest Research Station, 3625 93rd Ave. SW, Olympia, WA 98512*

This study represents an effort to examine the feasibility of accelerating the development of spotted owl habitat in managed forests by increasing structural and species diversity. We have adopted two means of approaching this issue: manipulation of the spotted owl prey base and silvicultural alterations. We are attempting to increase population densities of spotted owl prey (primarily northern flying squirrels) by providing additional nest sites for squirrels (artificial cavities and nest boxes). We are also creating wildlife thinnings, designed to maximize structural diversity (both horizontal and vertical) and growth of several strata of understory vegetation. We have gathered a year of baseline data and are currently beginning the experimental manipulations of our study plots.

BIODIVERSITY RESEARCH AT THE BLM'S PACIFIC FOREST AND BASIN RANGELAND SYSTEMS COOPERATIVE RESEARCH AND TECHNOLOGY UNIT

COLLOPY, M.W. *BLM Cooperative Research Unit, 3200 SW Jefferson Way, Corvallis, OR 97331*

The Pacific Basin and Rangeland Systems Cooperative Research and Technology Unit was recently established at Oregon State University, in Corvallis. Its location significantly enhances the opportunity for the BLM to develop stronger linkages with the scientific research and graduate education programs associated with Oregon State University and the PNW Research Station (USFS). Cooperative research programs are being implemented in both rangeland and forested ecosystems. The Vegetation Diversity Project is a research and demonstration program to improve the BLM's ability to restore and maintain native plant diversity on degraded semiarid lands in the Great Basin and the Columbia Plateau. Studies will examine the role of plant competition from exotic annual plants in the establishment of native perennials, the importance of seed source in restoration, the role of grazing animals in maintenance of diverse plant communities, and the potential effects of climate change on native plant diversity and on plant interactions. In western Oregon, biodiversity research at the stand and landscape levels is being developed to provide guidance to the management and conservation of managed and old-growth forest ecosystems on BLM lands. This research will assist in the development of alternative silvicultural systems that can be used to create desired characteristics in forested landscapes. A series of integrated studies are being designed to detect how the floral and faunal components of the landscape change in response to various management activities. This integrated approach will enable the Cooperative Research Unit to develop much needed landscape-level information on the status, stability, and distribution of plant and animal communities, as well as high-profile species (e.g., northern spotted owls, marbled murrelets, northern goshawks, and neotropical migrants), under various management regimes.

POPULATION CENSUS AND PRODUCTIVITY OF NESTING GOLDEN EAGLES, PRAIRIE FALCONS, COOPER'S HAWKS, SWAINSON'S HAWKS, AND FERRUGINOUS HAWKS IN CIMARRON COUNTY, OKLAHOMA

DAY, R.H., D.H. WOLFE, K.V. COLBERT, AND S.K. SHERROD. *G.M. Sutton Avian Research Center, P.O. Box 2007, Bartlesville, OK 74005*

As part of an ongoing study of prairie and prairie-edge nesting birds conducted by the Sutton Avian Research Center, population censuses and nesting productivity of Golden Eagles (*Aquila chrysaetos*), Prairie Falcons (*Falco mexicanus*), Cooper's Hawks (*Accipiter cooperii*), Swainson's Hawks (*Buteo swainsoni*), and Ferruginous Hawks (*Buteo regalis*) were conducted from 15 May 1992 through 18 July 1992 in Cimarron County, Oklahoma. Eight Golden Eagle nests were found, which produced a total of seven fledged young. Three Prairie Falcon nests were found, which produced a total of five fledged young. Four Cooper's Hawk nests were found, which produced a total of 11 fledged young. Thirty-five Swainson's Hawk nests were found, which produced a total of thirty-seven fledged young. Fifteen of the thirty-five Swainson's Hawk nests were destroyed by hail and/or high winds.

SATELLITE TELEMETRY OPTIONS FOR AVIAN RESEARCH

ELLIS, D.H. AND M.R. FULLER. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708*

Four manufacturers now produce transmitters in the size range suitable for raptors (3–5% of body mass). Dummies of these transmitters will be displayed and harnessing techniques will be demonstrated. Estimates will be given for: cost, reliability, longevity, mass, availability, programmability, power output and other information essential in deciding on manufacturer and model.

### HISTORICAL PRESENCE OF THE BURROWING OWL IN MEXICO

ENRIQUEZ ROCHA, P.L. *Ap. Postal 519, 77000 Chetumal, Quintana Roo, Mexico*

The Burrowing Owl (*Speotyto cunicularia*) has been listed in the Blue List since 1972 in the U.S.A. and classified as threatened in Canada. Northern banded Burrowing Owls have been recovered in Mexico and Central America. However, due to the scarce knowledge about the breeding and non-breeding distribution in Mexico, I compiled data on 279 Burrowing Owls from twenty-seven museums. Historical Burrowing Owl collects date since the 1840s through 1980s. Most of the individuals were collected in the decade of the 1900s. Sixty-three percent of collects were in the non-breeding (wintering) season. In Mexico, the Burrowing Owl has a wide distribution. It is located in 28 of 32 Mexican states. Baja Peninsula has provided the most information. The Southeastern region stands out for lack of information. *S. cunicularia* is the third most common owl collected in the country. The high number of individuals during the non-breeding season suggests an increase of Burrowing Owl populations. Possibilities may indicate the arrival of North American migrants at winter. I suggest finding breeding and non-breeding preferred and/or priority areas, banding individuals to define migration routes, and establishing the effects of human activities to determine if this impact affects the species' decline.

### OPPORTUNITIES AT THE ALASKA RAPTOR REHABILITATION CENTER

FORD, S., R. MAY, E. BEECHWOOD AND E. CRADDICK-PATT. *Alaska Raptor Rehabilitation Center, P.O. Box 2984, Sitka, AK 99835*

The Alaska Raptor Rehabilitation Center is located in Sitka, Alaska and was founded in 1980. Its three-part mission includes treatment of injured Alaskan birds of prey, education of the public concerning raptor ecology and medicine, and the support of research pertaining to the ecology and medical treatment of raptors. Although the center's beginnings were extremely modest, now it has grown to accommodate thousands of visitors a year and treats more than 50 bald eagles, its primary patients, each year as well as many other birds of prey and non-raptorial species. The staff at ARRC know that, although their efforts to save a few birds will not be significant in the overall population of raptors directly, the knowledge gained and shared from working with the birds will slowly awaken people to their significance and the magnitude of the impact that civilization has upon them. Being more aware of these elements, many of the preventable, man-caused injuries ARRC treats will diminish. ARRC invites others to share in its mission through volunteering, donation, and membership, and a special invitation is extended to raptor organizations and researchers to participate in ongoing research opportunities at ARRC.

### USE OF RANDOM AMPLIFICATION OF POLYMORPHIC DNA (RAPD) IN THE ANALYSIS OF METAPOPULATION STRUCTURE IN *STRIX* OWLS

GERHARDT, R., P. STACEY, A. HODGSON, S. GARLAND AND G. HOELTZER. *EEC Biology, University of Nevada, Reno, NV 89512*

Random amplification of polymorphic DNA (RAPD) is a comparatively new technique for detecting diversity in the nuclear genome. Relative to many other molecular genetic techniques, it is both time and cost effective. We are currently using RAPD to examine the degree to which small breeding populations of both Spotted Owls (*Strix occidentalis*) and Great Gray Owls (*S. nebulosa*) are genetically distinct from neighboring populations. We present here several examples of the type of results yielded by the RAPD technique. These results will enable us to construct population models that will in turn lead to a better understanding of the impact of various management strategies on these owl populations. In addition, we are exploring the applicability of the RAPD technique to questions of the phylogeny of the *Strix* complex and other closely related species.

### ARTIFICIAL STRUCTURES FOR NESTING FERRUGINOUS HAWKS IN TWO COUNTIES OF WASHINGTON STATE

HICKMAN, G.J. *Washington State Department of Wildlife, Spokane, WA 99218.* L. JURS AND T. THOMPSON. *Bureau of Land Management, N. 8702 Division St., Spokane, WA 99218*

Approximately sixty (60) nesting territories of Ferruginous hawks (*Buteo regalis*) are found in eastern Washington. Washington is on the margin of this species range, and often human activities in these areas have adversely impacted nest productivity. Furthermore, availability of suitable nest location is a problem for this species. In a cooperative effort to manage these populations in Lincoln and Franklin counties, the Bureau of Land Management and the Washington State Department of Wildlife have constructed and placed two types of nesting structures in an effort to help bolster productivity. One nest structure is circular metal, which is bolted to a basalt cliff. This device has been used to replace nests which have fallen from the cliff or on cliffs where nesting shelves are nonexistent. The second structure is used in conjunction with juniper and other tree nest locations. Construction of these nest structures provides nesting pairs with an option other than a ground nest, which may be vulnerable to predation

### USE OF GPS AND GIS TO STUDY BALD EAGLES AT AMERICAN FALLS RESERVOIR, IDAHO

HOWARD, R. *U.S. Fish and Wildlife Service, 4696 Overland Rd., Room 576, Boise, ID 83705*

Since 1980, standard bald eagle winter surveys have been conducted in the American Falls area in conjunction with the Idaho bald eagle survey. Data from these surveys were compiled with information from other standard survey routes throughout Idaho from the Raptor Research and Technical Assistance Center, Bureau of Land Management, Boise, Idaho. In 1991, the Bureau of Reclamation initiated a planning process with the U.S. Fish and Wildlife Service to develop a Resource Management Plan for the American Falls Reservoir area. A major objective was to assess the wintering and nesting bald eagle population in the 133 sq. mile study area. Monthly aerial surveys were conducted during the winter of 1992 for bald eagles using a Maule fixed-wing aircraft. The aircraft was equipped with a geo-positioning polycorder (GPS) which acquired electronically obtained locations of bald eagles observed during the survey using three satellites. An onboard computer stored the locations in LatiLong and UTM formats. A geographical information system (GIS) database was developed of the study area using ARC-INFO software. The stored locations of bald eagles were electronically transferred directly to the GIS, and color-coded map overlays were developed using a CalComp printer-plotter. Average number of bald eagles observed during the three surveys in 1992 was 73 (range 63–80). This falls within the range of bald eagles counted in the study area (range 41–114) since surveys were initiated in 1979. Bald eagles first nested successfully in the study area in 1991. In 1992, two pairs of bald eagles established territories and built nests. Both were unsuccessful at fledging young. Bald eagles attempting to nest in this area may be from the expanding population of 33 pairs found in the upper Snake River near Yellowstone National Park. The use of GPS to accurately map bald eagle locations during aerial surveys and the use of GIS to produce map overlays can be powerful tools for resource management agencies.

### THE STATUS OF THE BURROWING OWL IN NORTH AMERICA

JAMES, P.C. *Saskatchewan Museum of Natural History, Wascana Park, Regina, SK, Canada S4P 3V7*

The status of the Burrowing Owl (*Speotyto cunicularia*) in North America is reviewed. For each state or province, the breeding population is estimated within an order of magnitude, its trend is given, and factors affecting are presented.

### CHARACTERIZATION OF POPULATION AND FAMILY GENETICS OF THE BURROWING OWL BY DNA FINGERPRINTING

JOHNSON, B.S. *2321 Evenstar Lane, Davis, CA 95616*

Genetics attributes of the burrowing owl were revealed by DNA fingerprinting with the minisatellite probe pV47-2. I report here on DNA fingerprint variability, on fingerprint inheritance and rate of mutation, and on population substructuring. Each genetic profile comprised an average of 28.9 highly variable, somatically stable Mendelian markers, and contained single-locus, as well as multilocus, banding patterns, depending on hybridization stringency. Individual fingerprint specificity was minimally $8.4 \times 10^{-17}$, with an estimated mutation rate of 0.005. Allelic and genotypic frequencies at the pV47-2 locus indicated genetic substructuring within a pool of several geographically separated burrowing owl populations from western North America, and within a pool of populations from California, as well as inbreeding in an intensively studied California burrowing owl population. These results suggest that nonrandom breeding and population subdivision in this species may be occurring at very fine spatial scales, that levels of inbreeding may be elevated, and that burrowing owl genetic effective population size may be small. If local populations are genetically and demographically isolated from one another, local extinctions may be exacerbated, and recolonization from extant burrowing owl populations will be less likely.

### KLEPTOPARASITISM AMONG STELLER'S SEA EAGLES ON THE KAMCHATKA PENINSULA, RUSSIA

LADIGIN, A.V. *Kronotskiy State Biosphere Reserve, Kamchatka, Russia, 684010*

Feeding behavior by wintering Steller's sea eagles (*Haliaeetus pelagicus*) was studied on Kuril Lake on the Kamchatka Peninsula, Russia, from 1987 to 1992. Up to 700 eagles congregate here in winter to feed on sockeye salmon (*Oncorhynchus nerka*) carcasses. Kleptoparasitism (intraspecific food stealing) was studied in relation to food abundance, size of the food carcass, eagle group size, and eagle age ($N$ = 500 conflicts). Contrary to expectations, kleptoparasitism was most prevalent during periods of food abundance; it also was more frequent when eagles fed on the largest salmon carcasses. Kleptoparasitism increased exponentially as the size of the feeding group increased. Conflicts in small feeding groups were infrequent (0.5/min), compared to large groups (>5/min). Adult eagles were attacked by other eagles of all ages more than twice as frequently as subadults. Although aggression was common during feeding, communal feeding allowed all members of the group to more efficiently find and consume food. The evolution of kleptoparasitism, its energetics costs and benefits, its adaptive advantages, and the influence of eagle plumage coloration will be discussed.

### ANNOUNCEMENT OF THE NATIONAL TRAVELING RAPTOR DISPLAY

MARTELL, M. AND P. REDIG. *The Raptor Center at the University of Minnesota, 1920 Fitch Avenue, St. Paul, MN 55108*

The Science Museum of Minnesota (SMM), in collaboration with The Raptor Center at the University of Minnesota (TRC), announces the creation of a national traveling exhibition on raptors. This $3.5 million exhibit, which is partially funded by the National Science Foundation and the National Endowment for the Humanities, is scheduled to open in St. Paul, MN in June of 1994. Both the exhibit and related programs will be structured around the themes of biodiversity, ecology, and human relationships with nature. Both a 5000 square-foot version and a smaller version (less than 2000 square foot), will be produced and available for venues across the country. Collaboration between museums, zoos, nature centers, and raptor programs will be encouraged and can be modelled on the SMM-TRC collaboration. Activities and components will be designed for use in school programs in collaboration with the St. Paul museum magnet school. We are soliciting the loan or donation of museum quality artifacts relating to raptor biology, conservation, or falconry. Individuals interested in presenting the exhibit at their facility or in their town can begin booking in the fall of 1992.

## ARE AERIAL RADIOTELEMETRY LOCATIONS ACCURATE AND REPRESENTATIVE OF PRAIRIE FALCON ACTIVITIES?

MARZLUFF, J.M., M. VEKASY AND C. COODY. *Greenfalk Consultants, 8210 Gantz Ave., Boise, ID 83709*

Widely ranging raptors are difficult to radiotrack from fixed locations on the ground; therefore, we investigated the feasibility of tracking Prairie Falcons (*Falco mexicanus*) from a Cessna 182 airplane outfitted with a belly-mounted, rotatable, H antenna. We tracked beacons and falcons by homing on a signal, passing directly over the signal's source, and recording our location at that time with an on board global positioning system. Aerial tracking provided more accurate estimates of stationary and mobile beacons' locations than did ground-based tracking (95% confidence ellipses: mean air = 112 ha, mean ground = 875 ha). Aerial accuracy was not influenced by mobility of a beacon and was similar for two observers. Aerial tracking was efficient; thirty free-ranging, breeding falcons inhabiting a 110 km stretch of the Snake River Canyon were accurately located in a 3–4 hr flight. However, because these birds (especially females) spent a majority of their time in proximity of their aerie, most aerial fixes were close to the nesting territory. This resulted in significant underestimates of falcon foraging ranges. We conclude that aerial tracking is easy to learn, relatively inexpensive to implement, and very accurate. However, the extensive flight time required to consistently locate birds away from their aeries will preclude its application in typical studies of home range estimation.

## HOW DO YOU SUCCESSFULLY CAPTURE AND INSTRUMENT SPECIFIC PRAIRIE FALCONS (*FALCO MEXICANUS*) IN A DENSE NESTING POPULATION?

MCKINLEY, J.O., R.R. TOWNSEND, L.S. SCHUECK AND J.M. MARZLUFF. *Greenfalk Consultants, 8210 Gantz Ave , Boise, ID 83709*

During 1991 and 1992, we captured individual Prairie Falcons from specific nesting areas in the Snake River Birds of Prey Area and fitted them with radiotransmitters. We captured 67 Prairie Falcons using a dho-gaza with an owl lure (only 27% of the birds captured were non-targeted individuals). Captures of target birds were maximized by trapping close to the aerie when an individual was present. Capturing a specific sex was easiest during egg laying and early incubation; sets close to the aerie increased our likelihood of capturing females and those farther away were more likely to catch males. To minimize stress during capture, we put "shock absorbers" on the drags to reduce the force of the net's impact on the bird, placed the trap away from obstacles (rocks, steep slopes, sagebrush), and hid someone near the set to quickly retrieve a captured bird. To minimize stress during tagging, we banded and immediately released gravid females and kept other birds hooded and restrained in an abba. When instrumenting individuals, fit of the harness was emphasized and knots were glued and made inaccessible to falcons. We placed the harness's breakaway points on the anterior end of the transmitter to minimize the chances of entanglement while shedding the transmitter. Each radioed individual was monitored after release to assess individual adjustment to the transmitter and to allow for a quick response in case something went wrong. Our precautions succeeded—instrumented birds did not suffer any significant changes in behavior or productivity relative to controls.

## *ORNITHOCTONA ERYTHROCEPHALA* (DIPTERA: HIPPOBOSCIDAE): AN ECTOPARASITE FROM PEREGRINES IN GREENLAND

MEESE, R.J. *Division of Environmental Studies, University of California, Davis, CA 95616.* W.S. SEEGAR. *CRDEC, U.S. Army, Aberdeen Proving Ground, MD 21010-5423.* T. MAECHTLE AND M. ROBERTSON. *Greenland Peregrine Falcon Survey, 307 Blandford Ave., Worthington, OH 43085*

Ectoparasites infecting raptors have received scant attention. Adult peregrine falcons (*Falco peregrinus tundrius*) banded near Søndre Strømfjord, Greenland during summer 1992 served as hosts to several engorged ectoparasites The parasites were later identified as louse flies (Diptera· Hippoboscidae). The genus *Ornithoctona*, though widespread, has not been previously reported to occur on peregrines in Greenland.

## VARIABLE SCALES, VARIABLE CONCLUSIONS: PEREGRINE PREY IN GREENLAND

MEESE, R.J. *Division of Environmental Studies, University of California, Davis, CA 95616.* M.R. FULLER. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708*

Patterns in nature often depend upon the scales at which they are viewed, and many ecological phenomena are scale-dependent in both time and space. Birds were surveyed in West Greenland around six peregrine eyries and at six sites where no peregrines were known to nest to determine the effect of peregrines on passerine densities. The results of such analyses were found to depend upon the spatial scale at which an analysis was conducted. However, the patterns observed were robust through time. We urge other investigators to be alert for similar scale-dependent phenomena.

## RANGING DISTANCES OF GREENLAND PEREGRINES DURING THE BREEDING SEASON

PENNYCUICK, C.J. *Department of Zoology, University of Bristol, Bristol BS8 1UG, U.K.* M.R. FULLER. *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708.* W.S. SEEGAR. *Chemical Research, Development and Engineering Center, Aberdeen, MD 21010*

To estimate the area used by Peregrine Falcons during the breeding season in Westcentral Greenland, we radio-marked six adult males and four adult females. Location estimates of marked falcons were obtained from a Cessna 182 airplane, with one forward and side-pointing Yagi antenna, by homing to the signal. The location of the aircraft, while it passed around the radio signal, was estimated from the Global Positioning Satellite system using a Garmin 100 AVD receiver. Three of the nine nests at which peregrines were marked were unsuccessful. Seventy-four percent of the 336 total location estimates were obtained within 1.0 km of birds' eyries. Beyond 1.0 km, one female was detected at only 1–2 km, one male at 2–3 km, one male and one female at 3–4 km, one male no more than 4–5 km, three males and one female from 5–6 km, and one male between 6 and 7 km from their eyries.

## AGE IDENTIFICATION OF NESTLING AND FLEDGLING BURROWING OWLS

PRIEST, J. *Humane Society of Santa Clara Valley, 2570 Lafayette St., Santa Clara, CA 95959*

Two captive hatched Burrowing Owls were photographed each two days during the nestling and fledgling period to document exact age by down and feather progression. Photos will be displayed with other pertinent information.

## FALCONIFORMES FROM TUXTEPEC, OAXACA, MEXICO

REUTER CORTES, R. *Corina 117 A-12 Col. del Carmen, Coy. C.P. 04100, Mexico D.F. Mexico*

Considering avian diversity in Mexico, Oaxaca is one of the richest states in this country with both resident and migratory species. In the area of Tuxtepec, Oax. where a huge dam was recently built (about two years ago), a study has been carried out by people from the National University of Mexico (UNAM), who in 1989–90 reported the presence of 15 different raptor species in the area. The observations done in this study, in November 1991 and June 1992, report the presence of eight species previously unrecorded for the area. Considering the species previously reported and the ones found in this study, the total (23 species) represents 43% of the Falconiformes known for Mexico and approximately 8% of the species number known for the world. The results of this study show that this area can be of great importance for raptor biologists because of the number of species, both resident and migratory, that occur in the locality. Finally, it is important to mention that a lot of research on the different species is still needed in order to understand their biology, and ensure their permanence in the natural environment.

## BREEDING ECOLOGY OF THE CRESTED CARACARA (*POLYBORUS PLANCUS*) IN THE CAPE REGION, B.C.S., MEXICO

RIVERA-RODRIGUEZ, L.B. AND R. RODRIGUEZ-ESTRELLA. *Centro de Investigaciones Biologicas, Div. Biol. Terr., A.P. 128 La Paz 2 3000 Baja California Sur, Mexico*

The Cape Region of Baja California Sur has a permanent and abundant breeding population of Crested Caracaras (*Polyborus plancus*). Nevertheless, several changes have occurred the last two years in the region, changes that are affecting the nesting places of Crested Caracaras. For this reason, a study on the ecology of caracaras in the Cape Region began in 1987. During 1990, we studied the breeding ecology of the species, and the results of the study are presented here. Censuses along transect show that population densities of Crested Caracara range from 1.12 to 4.82 birds/km$^2$, being densest at the end of the breeding period. The breeding season was extended from February to August. The Crested Caracara nested mainly on cardon (*Pachycereus* spp., 76%), but it also used yucca (*Yucca valida,* 9.5%), teso (*Olneya tesota,* 4.7%), palmera (*Washingtonia robusta,* 4.7%), and paloverde (*Cercidium microphyllum,* 4.7%) ($\chi^2$ = 27.5; g.l. = 1; $P$ < 0.001; $N$ = 21). Nest height ranged from 3.5 to 8.5 m ($N$ = 22). The mean height of vegetal species used to support nests was 8.68 ± 2.85 m ($N$ = 21). The chamizo *Ruellia peninsularis* (69.2%) and alfilerillo *Condalia globosa* (61.5%) were the most used plants to build the nest. Nest re-use in 1990 was of 84.62% ($N$ = 13). Eighty-three percent of the nests used during 1990 were successful ($N$ = 16). The clutch size was two

or three, but we found a significant difference between the nests containing two fledglings and those with 0, 1 or 3 ($\chi^2 = 109.37$, g.l. = 3, $P < 0.01$). The diet of Crested Caracaras in the breeding season indicates a tendency both to have a broad diet breadth and to be an opportunistic species. Although the productivity of the species in the Cape Region was high (1.93 ± 0.85 young/attempt, $N = 16$), we believe the species will be threatened if human disturbance, deforestation, hunting and habitat loss are not stopped. We are concerned because "Los Cabos" are now suffering from the "tourism effect" and the increasing agricultural activities.

## PAIRED USE OF SATELLITE AND VHF TELEMETRY ON REHABILITATED BALD EAGLES

ROSE, E.F., W. ENGLISH AND A. HAMILTON. *Woodland Park Zoo, 5500 Phinney Ave. N., Seattle, WA 98103*

Two rehabilitated Northern Bald Eagles (*Haliaeetus leucocephalus alascanus*) fitted with backpack-mounted satellite tracking transmitters (PTTs) and tail-mounted VHF ground-tracking transmitters were released into the Skagit River Bald Eagle Natural Area (SRBENA) by the Woodland Park Zoo in Seattle. A juvenile female (90 hatch) was released in January 1991 and a sub-adult female (89 hatch) was released in January 1992. The paired use of satellite and VHF telemetry was tested to see if birds that left the vicinity of the release site could be relocated using the latest satellite location data as a starting point to begin a ground search using standard VHF telemetry. The juvenile female was tracked by satellite for six months prior to transmitter failure. The subadult female is currently being tracked by satellite eight months after release. Failure of the tail-mounted VHF transmitters after approximately four months each has prevented continued ground tracking of these birds. It was found that the paired use of satellite and VHF telemetry allowed longer term tracking and monitoring of individual rehabilitated eagles than was possible with VHF telemetry alone.

## IDENTIFICATION OF INDIVIDUAL OSPREYS BY USE OF PLUMAGE PATTERNS

RYMON, L.M. *Department of Biological Sciences, East Stroudsburg University, East Stroudsburg, PA 18301*

Individual ospreys often are difficult to distinguish in the field, particularly when unbanded or incubating deep in a nest. By observation of over 350 osprey including all four subspecies, I have developed a method of distinguishing individuals by head and upper body plumage patterns. During the 12-year study, comparisons were made in both the field and museums. The variations in patterns also make it possible to determine the identity of individuals in subsequent years. Long-lens photography and sketches were used to document plumage patterns which have proven unique and consistent. This method has been of great assistance during reintroduction programs in Pennsylvania and is recommended for field use.

## CRITERIA FOR DETERMINING AGE AND SEX OF NESTLING OSPREY

SCHAADT, C.H. *Wildlife Technology, Penn State, DuBois, PA 15801*

During the period 1984–87, the development of 63 nestling osprey, 33 males and 30 females, was monitored in 39 broods in North America. Eleven variables were measured on birds of known age and sex every other day until fledging. Using a combination of plumage and weight variables, which are easily measured and highly dimorphic, a method is presented to quantify age and sex-determining criteria suitable for use in field situations.

## FACTORS INFLUENCING THE DISTRIBUTION OF PEREGRINE FALCONS (*FALCO PEREGRINUS*) IN THE AUSTRIAN ALPS

SLOTTA-BACHMAYR, M.L. *Department of Zoology, Hellbrunnerstr. 34, 5020 Salzburg, Austria*

From studies of some species of birds of prey, we know that the availability of suitable nest sites and food supply are the main factors influencing their breeding distribution. For the Peregrine Falcon, some authors claim that there is some evidence for this relation but, until now, no quantified data has been available. A two-year survey of Peregrines in Salzburg county (Austria) showed that the distribution of this species is very irregular. The present study aims to shed more light on the situation by elucidating which factors determine the distribution of the peregrine and whether the species has a preference for specific types of habitat or for a particular range of altitudes. Between the two subareas (Calcareous and Central Alps) differences in the distribution of breeding pairs were found. Nesting sites in the Calcareous Alps are spaced regularly, while those sites in the Central Alps are spaced in a more random fashion. However, for both subareas there is a clear negative correlation between both elevation and prey density (individuals and biomass) and the "nearest neighbor distance" between breeding pairs. There was no significant preference for a specific habitat type. It seems that there are different factors influencing breeding distribution of peregrines in different parts of Salzburg county. In the Calcareous Alps, prey abundance is limiting breeding density whereas in the Central Alps, suitable cliffs are in short supply. This study quantifies the importance of different factors for population regulation of Peregrine Falcons and makes it possible to include these parameters in future management programs.

## RAPTOR ABUNDANCE IN SOUTHCENTRAL KENYA IN RELATION TO LAND-USE PATTERNS

SORLEY, C.S. *Department of Fisheries and Wildlife, Uni-*

*versity of Minnesota, 200 Hodson Hall, 1980 Folwell Ave., St. Paul, MN 55108.* D.E. ANDERSON AND P.F. MCINNES. *MN Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, University of Minnesota, 200 Hodson Hall, 1980 Folwell Ave., St. Paul, MN 55108*

We conducted nine road surveys for birds of prey from 12 January through 17 March 1990 in Nairobi National Park and in an adjacent area dominated by subsistence agriculture and livestock grazing in southern Kenya. We observed an average of 4.27 raptors/km inside the park and 0.40 raptors/km outside the park ($P < 0.005$). Excluding very abundant species [lesser kestrels (*Falco naumanni*) and vultures; 72.6% of all observations] and species associated with human settlements [black kites (*Milvus migrans*); 8.9% of all observations], raptors were observed more frequently in the park (0.47 raptors/km) than outside the park (0.23 raptors/km) ($P < 0.01$). Although species richness was similar inside (18 species) and outside the park (22 species), eagles, vultures, and lesser kestrels were seen more frequently inside the park and some infrequently observed species were only seen either inside or outside the park. These results reflect the differences in land-use practices inside and outside of the park, and suggest significant changes in raptor community structure (species richness, density, and species identity) related to human land use.

## EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES

STALMASTER, M.V. AND J. L. KAISER. *Stalmaster and Associates, 209 23rd Avenue, Milton, WA 98354.* S.K. SKAGEN. *National Ecology Research Center, U.S. Fish and Wildlife Service, Fort Collins, CO 80525*

For 5 years we studied how recreational activity affected wintering bald eagles (*Haliaeetus leucocephalus*) on the Skagit River Bald Eagle Natural Area (SRBENA) in Washington. Nearly 300 eagles wintered on SRBENA and fed on chum salmon (*Oncorhynchus keta*) carcasses, and up to 115 recreational events occurred each day (mean = 17 events/day). The number of eagles on the SRBENA was negatively correlated ($P < 0.001$) with the daily number of recreational events. Feeding activity declined exponentially ($P < 0.001$) with increasing recreational activity. Motorboats were particularly disruptive to feeding behavior. After 20 activity events per day, eagles still present were reluctant to feed, and after 40 events, feeding was nil. On weekends, when recreational activity was high, eagles fed 30% less than on weekdays, when activity was low. Eagles fed mostly in morning hours (64%), especially between 0900 and 1100 H (39%), and feeding disruptions were most pronounced during these hours. Number of feeding subadults declined faster than adults ($P < 0.05$) in the presence of recreational activity and subadults were slower ($P < 0.001$) to resume normal feeding after disturbances. Resumption of normal feeding was relatively fast after boat traffic (mean = 36 min), but slow after foot traffic (mean = 228 min). Under current levels of recreational use on the SRBENA, overall feeding activity was reduced by 35%. We recommend restricting recreational use, particularly motorboats and foot traffic, during morning hours to allow eagles to feed without being disturbed.

## COMPARATIVE EVALUATIONS OF HEMATOLOGIC PARAMETERS OF RED-TAILED HAWKS AND AMERICAN KESTRELS TRAPPED IN CALIFORNIA

STEIN, R.W., J.T. YAMAMOTO, D.M. FRY, N.D. OTTUM AND B.W. WILSON. *Department of Avian Sciences, University of California, Davis, CA 95616.* J.N. SEIBER, M.M. MCCHESNEY AND E.E. RICHARDSON. *Department of Environmental Toxicology, University of California, Davis, CA 95616.* V.J. JOSEPH. *Bird and Pet Clinic of Roseville, 4010 Foothill Blvd., Suite 106, Roseville, CA 95747*

Winter red-tailed hawks (*Buteo jamaicensis*) and American kestrels (*Falco sparverius*) were studied in the Modesto area to evaluate the risk presented to raptors from organophosphate (OP) dormant spray exposure. Blood was collected from 36 red-tailed hawks and 30 American kestrels during the dormant spray season (November–February) of 1990–91 and 1991–92. Additional samples from captive American kestrels and red-tailed hawks trapped in the Sacramento area are included in the analysis. Complete blood cell counts, hematozoa identification, and quantification of serum enzymes, protein, and electrolytes are reported. Age and sex differences of hematologic parameters will be presented. Correlation of hematologic parameters with OP residues will be examined to emphasize physiologic effects and symptoms of exposure. Supported by the Almond Board of California.

## RELOCATION OF BURROWING OWLS DURING COURTSHIP PERIOD

TERRILL, S.B. AND P. DELEVORYAS. *H.T. Harvey and Associates, P.O. Box 1180, Alviso, CA 95002*

In February 1990, five pairs of Burrowing Owls (*Speotyto cunicularia*) were translocated from Mission College, Santa Clara, California, to two adjacent sites in south San Jose, Santa Clara County, a distance of 19 linear miles. Owls were trapped, banded, and color-banded, held in hacking aviaries, and released into artificial burrows at relocation sites. Two pairs nested and produced nestlings by 15 May. One of these nests was successful and the second was destroyed by predator(s). Two female owls with failed nesting attempts returned to the Mission College site. In April 1992, two color-banded owls were observed at the south San Jose release site. In August 1992, one owl was recaptured at the original capture site. A second color-banded owl was found injured in August 1992, near the

original site. This owl later died due to complications resulting from probable impact with a vehicle.

### A Summary of Reproductive Success and Mortality in a Disturbed Ferruginous Hawk (*Buteo regalis*) Population in Northcentral Montana, 1990–92

VAN HORN, R.C. *Department of Biology, Montana State University, Bozeman, MT 59717*

The Kevin Rim is a sandstone escarpment in northcentral Montana. Ferruginous hawks (*Buteo regalis*) are common nesters along the rim, which is surrounded for several miles by the Kevin-Sunburst oilfield. The Kevin Rim area is considered a Special Management Area under the Bureau of Land Management's (BLM) Key Raptor Area program. Reproductive success and mortality were examined during two studies funded by the BLM. Dr. A.R. Harmata and M. Restani studied the impacts of petroleum development on breeding raptors of the Kevin Rim in 1990. This study was followed in 1991–92 by R.C. Van Horn, who examined the responses of raptors to these disturbances. Nest sites were observed from May to August in 1990, 1991 and 1992. In areas with little human disturbance, the number of fledglings produced per occupied nest varied from 2.20 in 1991 ($N = 6$) to 0.08 ($N = 11$) in 1990. In areas disturbed by petroleum development activities, the number of young per occupied nest varied from 2.60 in 1990 ($N = 12$) to 1.0 in 1992 ($N = 9$). No cases of ferruginous hawk mortality, either as fledgling or adult, could be directly attributed to oilfield activities. Two nests in 1992 had losses apparently due to starvation, but neither was in an area developed for petroleum extraction. Three cliff nests were destroyed during strong thunderstorms in 1992, and multiple nests were raided each year by mammalian and avian predators. Golden eagles (*Aquila chrysaetos*), prairie falcons (*Falco mexicanus*), great horned owls (*Bubo virginianus*), coyotes (*Canis latrans*) and red fox (*Vulpes vulpes*) were all possible sources of mortality.

### Reproductive Success of American Kestrels Nesting Along an Interstate Highway in Central Iowa

VARLAND, D.E. *Department of Animal Ecology, Science II, Iowa State University, Ames, IA 50011.* T.M. LOUGHIN. *Department of Statistics, Snedecor Hall, Iowa State University, Ames, IA 50011*

We studied the reproductive success of American Kestrels nesting in nest boxes attached to backs of highway signs along Interstate 35 in central Iowa, 1988–92. Nest box occupancy averaged 45 percent. All of the nest boxes faced either north or south, and there was no significant difference in nest box occupancy by nest box orientation. European Starlings built nests in nearly every nest box not occupied by kestrels. Kestrels evicted starlings from nest boxes, but starlings probably caused some kestrels to abandon their nests as well. Apparent nesting success, the percentage of nests fledging at least one young, averaged 69 percent. There was no significant difference in apparent nesting success by nest box orientation. Using the Mayfield method, we detected significantly lower probabilities of survival during the incubation stage in comparison with the brood rearing stage. Clutch size averaged 4.8 over the five years of the study, while mean hatching success was 62.5 percent. Mean brood size was 3.1, and the mean number of birds in a brood to fledge was 2.9. Fledging success, the percent of young hatched that fledged, averaged 91 percent. The reproductive success of kestrels in our study was similar to that of kestrels nesting in nest boxes attached to trees, utility poles, and buildings in other states. The highway sign provides a strong support, a high perch, and predators cannot easily climb to the nest. Across Iowa's agricultural landscape, nest boxes on interstate signs have given kestrels nesting opportunities that would not exist otherwise.

### Breeding Distribution, Population Trends, and Management of Five Diurnal Raptor Species in Washington State

WATSON, J.W. AND K.R. MCALLISTER. *Washington Department of Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091*

Statewide nesting surveys of bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus*), osprey (*Pandion haliaetus*), golden eagles (*Aquila chrysaetos*), and ferruginous hawks (*Buteo regalis*) were conducted over the past 8 to 17 years in Washington. Occupied peregrine falcon and bald eagle territories increased from 1 and 114 in 1975, to 17 and 444 in 1991, respectively. Population increases were pronounced on the Olympic Peninsula and Puget Sound. Productivity levels for both species remained near 1.0 yng./occ. terr. in 1991, although depressed productivity for bald eagles continued on the Lower Columbia River and Hood Canal. Osprey territories, distributed statewide except in southeast Washington, increased from 226 in 1984 to 412 in 1989, and productivity was high (1.49 yng./occ. terr.). The golden eagle population, consisting of 187 territories located mainly in northcentral Washington, experienced slight decreases in occupancy (49 percent to 41 percent) and productivity (33 percent to 26 percent) from 1985 to 1990. Preliminary analysis of 103 historic ferruginous hawk territories in eastern Washington indicated decreased occupancy and productivity from 1987 to 1992. Statewide management activities emphasized bald eagles and peregrine falcons; two biologists managed bald eagle habitats on a full-time basis, and the peregrine eyrie-attendant and captive-bred release programs continued from the 1980s.

### Reproductive Performance of Burrowing Owls (*Athene cunicularia*): Effects of Supplementary Food

WELLICOME, T.I. *Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 0W0*

I provided 14 of 28 Burrowing Owl pairs with extra food during the laying and incubation periods in 1992 to test the hypothesis that food availability limits reproduction. Supplementally-fed owls initiated laying 2 to 3 days earlier and laid approximately one more egg than did controls. Fed birds also tended to lay larger eggs than unfed birds. Hatchability did not differ between the two groups, but since food-supplemented pairs had larger clutches, they hatched more young. I conclude that food supply restricts egg, clutch, and brood size in breeding Burrowing Owls. These results could help explain the poor reproductive performance of owls nesting in areas where human activity may reduce habitat quality in terms of prey availability.

### KESTREL HABITAT USE AND PESTICIDE EXPOSURE DURING WINTER IN AGRICULTURAL AREAS OF THE CENTRAL VALLEY OF CALIFORNIA

YAMAMOTO, J.T., D.M. FRY, B.W. WILSON, R.W. STEIN AND N.D. OTTUM. *Department of Avian Sciences, University of California, Davis, CA 95616*. J.N. SEIBER AND M.M. MCCHESNEY. *Department of Environmental Toxicology, University of California, Davis, CA 95616*

Habitat use and home range information on wintering American kestrels (*Falco sparverius*) in California was collected for the purposes of pesticide exposure assessment and comparison with other raptor species under study. During the 1992 dormant spray season (January–February), thirty American kestrels were trapped in a 50 square mile area of heavy agricultural use in the Central Valley. All kestrels were foot-rinsed and blood-sampled for pesticide residues and plasma cholinesterase; eighteen birds were fitted with radiotransmitters prior to release. Tagged birds were monitored on a daily basis throughout the spray season and on a weekly basis until birds left the area or transmitter batteries ceased functioning. In addition to habitat use, data were gathered for roosting behavior, response of the birds to their transmitters (mounted in two different styles), transmitter and harness wear, and mortality. Five radio-tagged birds died during the study; four of these were probable predations, possibly by Cooper's hawks, while the fifth carcass was not retrievable. Three methods of home range calculations were compared using the GIS program CAMRIS: minimum convex polygon, density surface, and fixed buffer zones around observation points. Based on home range size and patchiness, and degree of usage of different habitat types suggested by each method, density surface was chosen as the most accurate and realistic type of calculation. Habitat use data suggested that open pasture or fallow field areas are of primary importance but that other types of agricultural habitat (e.g., orchards, vineyards, dairy, and poultry operations) are also utilized. Preliminary residue and biochemical analyses suggest low level exposure of kestrels to pesticides as a result of dormant spraying. Laboratory toxicological and behavioral studies on captive kestrels are underway to improve understanding of pesticide hazards to these and other wild raptors. Supported by the Almond Board of California.

## FILMS AND VIDEOS

### FIELD GUIDE TO THE RAPTORS OF THE WESTERN PALEARCTIC

CLARK, W.S. *4554 Shetland Green Rd., Alexandria, VA 22312*. J. SCHMITT. *11609 Alburtis Ave., Norwalk, CA 90650*

We are preparing a field guide to the raptors of Europe, North Africa, and the Middle East (Western Palearctic) for publication by Oxford University Press. The guide will consist of 48 color plates, an extensive text for each of the 49 species that occur there, and many color photographs. We will show slides of perched and flying raptors and the first eight color plates. The text will be similar in format to that in the North American raptor guide, coauthored by William Clark, but it will include a section on molt.

### A PHOTOGRAPHIC GUIDE TO NORTH AMERICAN DIURNAL RAPTORS

CLARK, W.S. *4554 Shetland Green Rd., Alexandria, VA 22312*. B.K. WHEELER. *P.O. Box 943, Longmont, CO 80501*

We are preparing a photo guide that will include 360 color photos showing all plumages of North American diurnal raptors, both perched and flying. It is intended as a companion to our raptor field guide, published in the Peterson series, and will be published by Academic Press. Each species account will consist of a short text and extensive photo captions for every photo. We will show a sample of photos to demonstrate the quality (closeness, sharpness, lighting) of the photos to be used. The complete set of photos of the Bald Eagle will be shown. These will show the field marks to correctly age all Bald Eagles, both in flight and perched.

### SKYDIVING WITH AN IMMATURE MALE PEREGRINE

FRANKLIN, K. AND S. FRANKLIN. *2959 San Juan Valley Road, Friday Harbor, WA 98250*. T. DONALD. *425 East End, SK, Canada*

We attempted to determine the terminal diving speed of a male peregrine by training the peregrine to stoop after a skydiver in free fall trailing a lure.

INTIMATE OBSERVATIONS OF CAPTIVE BREEDING OF WILD, DAMAGED BURROWING OWLS OF GREAT PLAINS STOCK FOR RELEASE OF YOUNG

MCKEEVER, K. *The Owl Rehabilitation Research Foundation, 21st St., RR 1, Vineland Station, Ontario, Canada L0R 2E0*

Color video with remotely controlled pan, tilt and zoom focuses on one family (of five families in 3600 sq. foot breeding complex) of Great Plains origin Burrowing Owls, as five fledglings emerge from underground tunnels 2½ meters from nest chamber. Scenes include parental feeding, development of the young owls from poor physical coordination to beginning hunting prowess, sibling competition, juvenile response to parental warning of overhead threat, sunning, preening, grooming and instinctive, though ineffectual, sand scuffing on burrow mound. Juvenile behavior near the home burrow demonstrates the extreme vulnerability to predation from land or air of these early fledglings, when clumsiness and inattention are most apparent.

THE ADVANTAGES PROVIDED BY AERIAL CORRIDORS BETWEEN COMPOUNDS IN ALLOWING RESIDENT OWLS TO FORM EFFECTIVE BONDS THROUGH CHOICE

MCKEEVER, K. *The Owl Rehabilitation Research Foundation, 21st St., RR 1, Vineland Station, Ontario, Canada L0R 2E0*

This is a remotely controlled video of successful breeding of wild, permanently damaged Northern Hawk Owls through the ability to self-select potential mates. The female of this pair had occupied a 600 sq. foot divided compound for five years, sharing the total space with first one, then another, arbitrarily introduced wild males without any evident bonding behavior. In the winter of 1992, a 12-foot-long aerial flight tunnel was suspended across to another compound containing two other males and a female—all damaged wild Hawk Owls. Immediately, the five-year resident female flew across the corridor, began negotiations with both males, apparently selected one (who followed her back up the corridor to her own long-held territory), drove out the incumbent, and commenced egg-laying—all in the space of four (4) days! The successful issue of three young is shown in nestling, fledgling and early flighted stages.

LOSING GROUND: A CALIFORNIA BURROWING OWL STORY

STENDER, S.A. *Scott A. Stender Video Productions, 306 Starling Road, Mill Valley, CA 94941*

The program is a look at the habitat loss problems facing California burrowing owl populations. Interviews with biologists and land managers are interspersed with natural history footage of the owls.

*The Journal of Raptor Research* is distributed quarterly to all current members. Original manuscripts dealing with the biology and conservation of diurnal and nocturnal birds of prey are welcomed from throughout the world, but must be written in English. Submissions can be in the form of research articles, letters to the editor, thesis abstracts and book reviews. Contributors should submit a typewritten original and three copies to the Editor. All submissions must be typewritten and double-spaced on one side of 215 by 280 mm (8½ × 11 in.) or standard international, white, bond paper, with 25 mm (1 in.) margins. The cover page should contain a title, the author's full name(s) and address(es). Name and address should be centered on the cover page. If the current address is different, indicate this via a footnote. Submit the current address on a separate page placed after the literature cited section. A short version of the title, not exceeding 35 characters, should be provided for a running head. An abstract of about 250 words should accompany all research articles on a separate page.

Tables, one to a page, should be double spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be pencilled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (6th ed., 1983) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1990).

Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 24(1–2), which is available from the editor.

## 1993 ANNUAL MEETING

The Raptor Research Foundation, Inc. 1993 annual meeting will be held on 3–7 November at the Marriott City Center Hotel in Charlotte, North Carolina. Details about the meeting and a call for papers will be mailed to Foundation members in the summer, and can be obtained from Keith Bildstein or Laurie Goodrich, Scientific Program Chairpersons, Hawk Mountain Sanctuary, Rural Route 2, Box 191, Kempton, PA 19529-9449 U.S.A. Telephone (215) 756-6961, FAX (215) 756-4468. For futher information about the meeting or the associated art show, contact Robert Gefaell, Local Chairperson, P.O. Box 16443, Charlotte, NC 28297 U.S.A. Telephone (704) 334-8078 or (704) 875-6521 (Carolina Raptor Center). For information about the associated symposium "Raptors Adapting to Human Environment," contact David Bird, Raptor Research Centre, McGill University, 21,111 Lakeshore Road, Ste. Anne de Bellevue, Quebec, Canada H9X IC0. Telephone (514) 398-7760, FAX (514) 398-7983.

## Raptor Research Foundation, Inc., Awards

### Recognition for Significant Contributions[1]

The **Dean Amadon Award** recognizes an individual who has made significant contributions in the field of systematics or distribution of raptors. Contact: **Dr. Clayton White, 161 WIDB, Department of Zoology, Brigham Young University, Provo, UT 84602 U.S.A.** Deadline: August 15.

The **Tom Cade Award** recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. Contact: **Dr. Brian Walton, Predatory Bird Research Group, Lower Quarry, University of California, Santa Cruz, CA 95064 U.S.A.** Deadline: August 15.

The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Contact: **Dr. David E. Andersen, Department of Fisheries and Wildlife, 200 Hodson Hall, 1980 Folwell Avenue, University of Minnesota, St. Paul, MN 55108 U.S.A.** Deadline: August 15.

### Recognition and Travel Assistance

The **James R. Koplin Travel Award** is given to a student who is the senior author of the paper to be presented at the meeting for which travel funds are requested. Contact: **Dr. Michael W. Collopy, Director, Cooperative Research Unit, Bureau of Land Management, Forest Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331 U.S.A.** Deadline: deadline established for conference paper abstracts.

The **William C. Andersen Memorial Award** is given to the student who presents the best paper at the annual Raptor Research Foundation Meeting. Contact: **Dr. Keith Bildstein, Hawk Mountain Sanctuary, Rural Route 2, Box 191, Kempton, PA 19529-9449 U.S.A.** Deadline: Deadline established for meeting paper abstracts.

### Grants[2]

The **Stephen R. Tully Memorial Grant** for $500 is given to support research, management and conservation of raptors, especially to students and amateurs with limited access to alternative funding. Contact: **Alan Jenkins, George Miksch Sutton Avian Research Center, Inc., P.O. Box 2007, Bartlesville, OK 74005-2007 U.S.A.** Deadline: September 10.

The **Leslie Brown Memorial Grant** for $500–$1,000 is given to support research and/or the dissemination of information on raptors, especially to individuals carrying out work in Africa. Contact: **Dr. Jeffrey L. Lincer, BioSystems Analysis, Inc., 13220 Evening Creek Drive South, Suite 119, San Diego, CA 92128 U.S.A.** Deadline: September 15.

[1] Nominations should include: 1) the name, title and address of both nominee and nominator, 2) the names of three persons qualified to evaluate the nominee's scientific contribution, 3) a brief (one page) summary of the scientific contribution of the nominee.

[2] Send 5 copies of a proposal ($\leq$5 pages) describing the applicant's background, study goals and methods, anticipated budget, and other funding.